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WORKS BY DAVID SALMON,

Principal of the Training College, Swansea.

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LONGMANS'

OBJECT LESSONS

HINTS ON PREPARING AND GIVING THEM

WITH FULL NOTES OF

COMPLETE COURSES OF LESSONS

ON

ELEMENTARY SCIENCE

BY

DAVID SALMON

PRINCIPAL OF THE TRAINING COLLEGE, SWANSEA
AUTHOR OF 'LONGMANS' SCHOOL GRAMMAR' AND 'SCHOOL COMPOSITION'

SIXTH IMPRESSION

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LONGMANS'

OBJECT LESSONS

PART I

HINTS ON PREPARING AND GIVING LESSONS

SHOULD SCIENCE BE TAUGHT?

Considerations which should influence the choice of subjects of instruction.

STUDENTS of education who are engaged in the actual work of instruction are frequently forced to think *how*, but rarely *why*, any given subject should be taught. Every teacher must himself answer the first question; the second is generally answered for him. Authority or custom decides that certain subjects shall be taught and that certain other subjects shall not be taught: hence there is no room for choice except among that class of subjects concerning which authority is silent and custom speaks with varying voice. That class at present often includes science, and before we can decide whether science should be taught, we must examine the principles that ought to determine the admission of any subject into a well-considered course of studies.

The first principle is practical value. School life is a pre-

paration for the wider life to follow, and it is the duty of a teacher to provide his pupils, as far as possible, with the knowledge which they will require after they have passed from under his care. If, for instance, they were all going to be physicians, it would be his duty to give them as much instruction in anatomy, physiology, chemistry, and *materia medica* as they had time and capacity to receive. The same remark applies to every other calling. But, as a rule, the teacher does not know what are the occupations before his pupils, while he does know that these occupations are many and diverse, and that he has no time to teach even the rudiments of any of them. It, therefore, is his duty to prepare children, not for one trade or profession, but for all; it is his duty not to make them doctors or lawyers, shopkeepers or artisans, but to make them men and women with faculties well developed and minds well stored with information that cannot fail to be of service in any walk of life. His aim must be the greatest usefulness to the greatest number. Consequently those subjects ought most frequently to appear in courses of study, a knowledge of which is most frequently required in practical affairs. Reading, writing, and arithmetic are taught to every pupil in every school, because every pupil after leaving school finds a knowledge of them essential.

1. Utility.

The second principle that ought to regulate the admission of any subject into a course of study is educative value. The muscles grow and are strengthened by use, and as work and the ordinary activities of life are likely to produce a disproportioned and partial development of the body by unduly exercising some of the muscles while leaving others unexercised, gymnastics have been invented. Now, the fact that most men go through life without being called upon to exhibit acrobatic skill is no argument against gymnastics. We practise them not because we think that some day we may

2. Educative value.

be called upon to swing on a trapeze, vault over parallel bars, or handle dumb-bells and Indian clubs, but because we know that they make the body fitter for the performance of whatever operations it may be required to undertake. What is true of the body is also true of the mind. The mental faculties grow and are strengthened by exercise, and we pursue certain studies not because we think we shall be called upon to apply them, but because we know that they make the mind fitter for the performance of whatever operation it may be required to undertake. Algebra and Euclid are cases in point. No one who knows these subjects would deny that they have immense practical value, but we do not teach them solely, or indeed mainly, because of that. Though we might be quite sure that none of our pupils would ever apply his knowledge of algebra or of Euclid, we should continue to teach both for the sake of the mental development that the study of them brings. Algebra trains the mind to deal with abstractions and generalisations, and Euclid to make correct deductions from stated premises, and though skill in mathematics may to many persons be of little practical value, skill in abstract and deductive reasoning must be of great importance to everyone.

The third principle that ought to regulate the admission of a subject into a course of study is æsthetic enjoyment. Literature and art are taught not so much because of their practical or educative value, as because they tend to refine and elevate the mind and add largely to the innocent pleasures of life.

3. Pleasure.

Applying to a particular case the three general principles thus laid down, what are the claims of science to a place in every school curriculum? If based on only one of the three, its claim deserves consideration; if based on two, it is very strong; and if on the three, it is irresistible. The utility of science is now universally admitted.

The claims of science.
1. Utility.

Science helps to satisfy the first and strongest demand of nature—the demand for self-preservation. Increased knowledge of the laws of sanitation, with increased obedience to them, has in the last half-century added ten years to the average length of human life, and has, at the same time, made life more enjoyable and more useful because more healthy. And the limit of improvement is far from being reached yet. Thousands of babies still die annually from their mothers' ignorance of infant digestion and the constituents of food, and thousands of men and women contract avoidable diseases from ignorance of hygienic laws. Besides preserving health and prolonging life science adds to our comforts and conveniences. Steam and electricity are only two of the forces that it has enlisted in our service, and yet, deprived of these two, existence to the modern man would hardly seem worth having. Science is, moreover, the foundation of every art and manufacture carried on among civilised people. If, therefore, any subject can claim to be taught in schools because of its utility, surely science can.

The claim of science to be taught for the purpose of developing the faculties is also incontrovertible. Every physical science begins with the careful and intelligent observation of facts and then proceeds to classify and generalise; hence the pursuit of it gives a keenness to the senses and a vigour to the reasoning powers which must be of immense value in any department of human activity. Each faculty trained by the study of science may perhaps be trained by the study of some other subject, but no other subject trains *at once all* the faculties trained by science.

2. Educative value.

The study of science also adds to the pleasures of life. Where another person might see only a dull flat country and a soil as void of interest as of crops, one who knows something of botany and zoology sees open before him a fascinating page in the great book of nature. Every

3. Pleasure.

blade of grass, every tuft of moss, the butterfly that crosses his path, the lark that mounts aloft, is for him instinct with meaning and delight. A starry sky is to everyone a beautiful picture. To the astronomer it is that and much more. Every brilliant point is to him as the face of an old friend; he knows its name and its history, and looks for its return at the appointed time. And so with every other science. We cannot study one which shall not add interest to every country walk, to every excursion on river, lake, or sea, even to every journey by rail. It was the loss of innocent pleasure, not of useful information, that Carlyle deplored when he said: 'For many years it has been one of my most constant regrets that no schoolmaster of mine had a knowledge of natural history, so far at least as to have taught me the grasses that grow by the wayside, and the little winged and wingless neighbours that are continually meeting me with a salutation which I cannot answer as things are. Why did not somebody teach me the constellations, too, and make me at home in the starry heavens which are always overhead, and which I don't half know to this day?'

In our time the most powerful and the most uncompromising advocate of the study of science is Mr. Herbert Spencer, but

Mr. Herbert Spencer.

he has somewhat weakened his own case by overstating it. He argues or takes for granted that the greater part of school time should be devoted to science; that every pupil should master every science which is applied to practical purposes; and that the chief end of education is the acquisition of useful information. Most of those who have examined the principles of pedagogy will agree with Mr. Spencer that science should have a place—should have a large place—in every curriculum, but this does not commit them to accepting all his contentions or assumptions. Except when it is the business of our lives to apply some science practically, we study it in order that our faculties may

be developed, and that we may be able to take an intelligent interest in the world around us. Utility is only one, and not necessarily the first consideration; hence it would not be wise, even were it possible, to master every *-ology*. Surely Mr. Spencer is wrong in thinking that science, long the Cinderella of the schools, should henceforth queen it over her elder sisters, literature and art; and those are equally wrong who think that she should be driven back to her old station in the kitchen.

WHEN SHOULD SCIENCE TEACHING BEGIN?

Young children are incapable of the formal study of science.

ASSUMING that science is to be taught to all, when should the teaching begin? What has already been said about the educative value of the subject points to the answer. The study promotes the growth and vigour of the faculties employed in observation, classification, generalisation, and inductive reasoning; but of these only the faculties employed in observation are active in young children, the others being either dormant or altogether absent. It is therefore obvious that a complete and rigid study of science is beyond the capacity of young children, and that such study should begin only when the powers of abstract thought are sufficiently developed. This they are believed to be in ordinary cases at the age of twelve to fourteen, and to attempt the teaching of severe science before that age has been reached is to don the armour of Saul on the body of David.

But it does not necessarily follow that no scientific teaching should be given before. It is true that *all* the requisite faculties are not present in young children; but those that are present should be trained from the first, and the training of the

rest should begin as soon as they manifest themselves. The very baby in arms begins to observe. As soon as he has attained to speech, he is full of questions about the objects around him and the phenomena of daily life. If his natural curiosity is wisely satisfied and directed, a broad and deep foundation is already laid for future scientific teaching; but, should his curiosity be suppressed or left without guidance, the absence of a body of sound observation to form a basis for scientific teaching is only one, and that not the greatest, of the resulting evils. A greater evil is the undeveloped state of the perceptive faculties themselves. A professor of geology in one of the American Universities says: 'I feel daily that the efficiency of my work as a student and teacher of science is marred by the vice of early education, which repressed rather than developed whatever powers of observation nature had given. My professional life has been a perpetual struggle to rid myself of some of the mental habitudes induced by an unnatural education. . . . And what I have felt in myself I have seen in my students. It is worse than making bricks without straw to teach natural science to college juniors and seniors in whom disuse has wrought so complete an atrophy of the powers of observation that they hardly know that there is an external universe.'

The perceptive faculties are manifested early and should be trained early.

This, then, is the answer to the question, 'At what age should the teaching of science begin?' The complete and formal teaching of any science can begin only when the powers of abstract thought have begun to manifest themselves—that is, only when the child has reached the age of twelve to fourteen; but teaching calculated to develop the faculties required for the study of science must begin even in the infant school. If there were no other argument in favour of beginning thus early, there is an incontrovertible argument in the fact that the school education of

When should science teaching begin?

the majority of our children ends before the time for the definite study of science has arrived, and that if they are not trained in the infant school and the lower classes of the primary school to perceive physical truths, and, in a measure, to reason from what they perceive, they will be forced to go through life without the help of intellectual implements and tools that might have been theirs.

Object Lessons a substitute and preparation for science teaching.

Courses of Object Lessons, arranged with some regard to the laws of psychology, prepared with care and given with skill, by directing the attention of children towards tangible things, by encouraging them first to observe, then to compare, and finally to classify and generalise, furnish, not indeed an equivalent for definite science teaching, but the best substitute possible in the case of those who leave school at an early age. Such Object Lessons are, moreover, the best preparation for it, because they place the pupil in the right road and lead him some way along it. When he begins the study of science he has simply to go further and faster in the same direction—he has simply to make more minute observations, more comprehensive comparisons, more distinct classifications, and more sweeping generalisations.

SUBJECTS OF LESSONS

Principles underlying courses.

In the planning of courses and in the preparation of the lessons themselves two principles must be kept steadily in view:—

1. The end to be aimed at must be clearly understood, and the courses so arranged that they shall lead up to that end.

2. The lessons must be adapted to the successive stages of mental growth through which the children pass.

Ends to be aimed at.

The ends to be aimed at are three :—

1. The cultivation of the perceptive powers.

2. The communication of useful knowledge.

3. The cultivation of the powers of generalisation and of inductive reasoning.

With the youngest children the first must be the end chiefly aimed at, with the eldest the third. The second should be kept in view in all the lessons, but should not be allowed to dominate any.

Subjects which should be chosen.

The earliest lessons should be on the common objects and the common animals to be seen in the home, the school, the streets, and the fields. The children should be made by the use of their own senses, aided by judicious questions from the teacher, to perceive the forms and chief properties of the objects and the most striking characteristics of the animals. A little later there should be lessons on common natural phenomena, such as clouds, mist, rain, snow, and thunder. Gradually the range of observation should be extended till it includes typical selections from the animal, the vegetable, and the mineral worlds, and the simplest elements of physics and biology. Finally, Object Lessons should give way to definite lessons on those sciences towards which all the courses have been gradually tending.

Having regard to the fact that the powers of children are constantly developing, it is obvious that several lessons may be given on the same subject at successive stages. Three lessons may, for example, be given on coal, the first dealing with its more obvious properties, the second with the mining, and the third with the origin of it.

In looking over actual courses of Object Lessons one is often

struck by the fact that they include lessons which must be given without any appeal to the senses, and which, therefore, cannot, properly speaking, be Object Lessons at all. I have seen[1] included lessons on Miltiades, Alexander the Great, Hannibal, and Julius Cæsar; on Martin Luther, Mohammed, Frederick the Great, and Napoleon; on Scott's Novels and Shakespeare's Plays; on Drake, Cook, Franklin, and Livingstone; on Arctic and on African Exploration; on Honesty, Truthfulness, Temperance, and Kindness; on Thrift, Wages, Strikes, Supply and Demand, Money, Rent, Taxes, Trial by Jury, and the Making of Laws. No one will deny the extreme desirability of giving lessons on most of these subjects; all that I contend for is that they should not be included in a course of *Object* Lessons.

Subjects which should not be chosen.

Granted that every subject chosen may rightly be included, the arrangement of the subjects into series remains. The three chief points to be considered here are:—

Arrangement of lessons in courses.

1. That each lesson shall be placed in that part of the series where it shall be most suited to the stage of mental development reached by the class. An observation lesson on the properties of chalk, for example, would be too simple for children of eleven or twelve, while one on the composition and origin of chalk would be too difficult for children of seven or eight. The first would convey no information because most of the facts would be familiar, and the second would convey little because most of them would be unintelligible. The first would make no demands, and the second would make impossible demands upon the powers of the children; neither

[1] I hope that the fact of its having been my duty to hear and criticise the lessons of hundreds of teachers will be allowed to excuse occasional reference to what has come under my own notice.

therefore, would interest or instruct; neither would possess any value, practical or educative.

2. That the lessons shall follow one another in logical order and coherence. All the information that is necessary to a complete understanding of the second should be given in the first; of the third in the first and second. A lesson on the composition of air, for example, should follow, not precede, lessons on the constituent gases.

3. That the lessons shall lead directly to the end proposed. It has already been shown that Object Lessons form the best preparation for definite science teaching, and both in the choice and the arrangement of the subjects the particular science or sciences to be taught ought always to be kept in view.

MATTER OF LESSONS

The subject of the lesson being decided upon, the teacher has next to decide what he shall say about it. It would be as impossible to teach as it would be unwise to try to teach all the facts available, and a selection has to be made varying with—

Matter of lesson should vary with

(1) The age of children,

(2) What they already know of the subject,

(3) The time allotted to the lesson.

1. If the children are young, the teacher will dwell chiefly upon the simple facts which they can find out by the exercise of their senses and the simple inferences which they can be led to make, while he will avoid technical terms, difficult generalisations, and complicated explanations. If, for instance, a lesson were to be given to children of seven or eight on the parts of a flower, the teacher would show the parts in different specimens till the children could recognise

1. Age of children,

them under their varying forms, but he would say nothing of the functions of the parts or of their botanical names. On the other hand, if a lesson on the same subject were given to children of eleven or twelve, great stress would be laid on the functions, and the botanical names would be introduced. Similarly, if the lesson were on a manufacture, the teacher would with the younger children demonstrate the essential qualities of the raw material, and give only the broadest outline of the successive processes; whereas with the elder children he would almost assume an acquaintance with the qualities, and give pretty full details of the processes.

2. Their previous knowledge.

2. If what the children have already learned is not taken into account in the choice of matter, their time may be wasted in an attempt to teach them what they know, or the foundations laid in previous lessons may be ignored, and the old instruction may not be made to serve as a basis for the new.

3. Length of lesson.

3. When the teacher in preparing a lesson does not bear in mind the number of minutes at his disposal he may provide too little matter or too much. If there is too little, he is likely to use vain repetitions in order to occupy the allotted period. If, on the other hand, there is too much, he is likely to hurry through it, teaching nothing effectively, or to teach the first part effectively and to omit the last part altogether. In the first case the lesson is vague, in the second unsymmetrical; in either case no foundations are laid for the next lesson in the series.

Things, not words.

With regard to the choice of matter a word of caution may, perhaps, be necessary. An Object Lesson is a lesson on objects, not on language. Incidentally and indirectly it may teach new words or give clearer notions of the meanings of old ones, but when it is deliberately made the medium of instruction in language its purpose is entirely mis-

understood. Perhaps the greatest and most common mistake in this respect is unintentional. I have heard a teacher who had to give a lesson on Leather, and who fully believed that he was doing all that could be expected of him, spend more than half his time, not in trying to show that the substance is odorous, flexible, opaque, &c., but in trying to explain the terms *odorous*, *flexible*, *opaque*, &c. A satisfactory lesson might be given on the Properties of Leather by first demonstrating how many of them are found in the original hide and how many are imparted in the manufacture, and then by explaining how the various uses of leather depend upon the possession of them; but that would be a lesson on the properties, not on the meaning of certain hard words employed to denote them.

Arrangement of matter.

The next step after the selection of the matter is the arrangement of it; but here no very definite directions can be given, because an arrangement which is bad in one set of circumstances may be defensible in another. To begin a first lesson on the Cat, for example, by saying that the animal belongs to the sub-kingdom vertebrata, to the class mammalia, the order carnivora, and the family felidæ would betray gross lack of judgment and gross ignorance or disregard of psychology, whereas to begin thus might be justifiable after a large number of lessons had been given on typical animals and on the principles of classification.

1. Should be natural.

1. The first general direction with regard to arrangement is that the facts should be presented in a natural order. The teacher should consider what are the processes by which children, if left to themselves, acquire knowledge, and he should imitate those processes as far as may be consistent with obtaining more definite results in a briefer period. If, for instance, a lesson had to be given on Lakes, Rivers, and Canals, the teacher should remember that children at first note only the presence of water. Then they note the

differences between the three bodies—the water of a river moves, while that of a canal and of a lake is (practically) at rest; a lake is broad in proportion to its length, while a river and a canal are long in proportion to their breadth; a river winds, while a canal is almost straight; a lake and a river are natural, while a canal is artificial. Finally, they learn, by wider observation, or the information of their seniors, that the lake, river, and canal familiar to them are typical, and they are then ready for classifications and definitions. To begin, therefore, with classifications and definitions, as young teachers, copying the method adopted in text-books (perhaps for convenience of reference) often begin, is to reverse the order of nature.

2. New knowledge should be joined to old.

2. That part of the subject which most readily connects itself with the previous knowledge of the children should be placed first. New ideas, when not arising from the presentation of new objects, must be formed by the modification of ideas already possessed. The idea, for example, which a child who has not seen a lake forms of it is a modification of his idea of a pond. If a new topic introduced is not brought into relation with what has gone before it must fall for want of support. Furthermore, association is the most valuable principle in mnemonics, and the connecting of the new idea with the old is a great help to the remembering of both.

3. Eliciting.

3. A mental survey of all the information to be conveyed will sometimes show that if certain facts were presented first all the rest would follow naturally in a train of inductive reasoning. If a lesson on the Swallow, for instance, began with the food, the teacher could make the children infer that the bird can be with us in summer only, that it must live chiefly on the wing, and that its structure must, therefore, be what it is.

4. Whatever may be the starting-point, the lesson should progress from it without break or turning. If a teacher, for example, giving a lesson on the Chemistry of a Candle began with the products of combustion, he would have to go back in order to show whence they are derived.

4. Directness.

5. There should be no attempt at a uniform arrangement of the matter. Young teachers have a tendency to stereotype. I have seen a score of lessons on the same subject arranged exactly alike. They all began with an 'Introduction,' proceeded to 'Properties,' and (after intervening heads) ended with 'Uses.' A formal introduction is sometimes useful and sometimes necessary. It is useful when the teacher is skilful enough by means of it to awaken interest in what is coming. It is necessary when a reference to preceding lessons forms the basis of the teaching about to be given. In all other cases it may be omitted with advantage. 'Properties,' too, may be omitted when they are obvious, when the children are familiar with them already, or when they have no bearing on what is to follow. The same remarks apply to 'Uses,' and, as a general rule, it is bad to separate 'Properties' and 'Uses,' for the second depend upon the first.

5. Arrangement should not be stereotyped.

NOTES OF LESSONS

In school work, as in all other work, forethought and labour are the price of success, and a teacher who tries to give a lesson without adequate preparation courts failure. It is not enough for him to have a general or even a minute knowledge of his subject. He must consider what are the facts to which he will draw attention, which of these he must tell and which he can elicit, what is the best order for

The need for notes.

presenting them, what illustrations will throw most light upon them, and what exercises will most deeply impress them upon the minds of his pupils; and experience has shown the advantage of noting down these points.

The fulness of a teacher's notes of a lesson will depend largely upon whether they are meant for his own use alone or for the inspection of another. If for his own use alone, they will, so long as he is dealing with a familiar subject, give only the heads of the matter, and brief hints of the methods and illustrations. When the subject is unfamiliar the matter will be given much more fully.

Full or brief notes.

Pupil teachers in elementary schools, students in training colleges, and all who submit to the examinations of the English Education Department, have very often to write notes, not for their own use, but to show a master, inspector, or other critic how they would give a set lesson. In these cases the notes must be self-explanatory, and indicate clearly both what would be taught and how it is proposed to teach it. Granting that the execution of the lesson is equal to its conception, these full notes would give a reader almost as good an opportunity as a hearer would have had of estimating the skill of the teacher, but this implies that they should, in addition to presenting a clear outline of the matter, show the method with considerable fulness. Such meagre directions as 'Elicit,' 'Deduce,' 'Draw from children,' 'Get this from class by questioning,' are useless, because exactly how the teacher is going to elicit, deduce, draw from the children, or get from the class by questioning is just what one wants to know. A minute description of the process might be tedious, but an outline of it should be given sufficiently full to convey clear notions to anyone who has the technical knowledge necessary to the understanding of it.

Full notes.

Notes intended for inspection by others than the writer are

in England generally set forth in one or two forms. Either the hints on method are intermingled with the matter, as in the lessons given in this book, or the matter and method are kept distinct, as in the lesson on the Cat given in the Appendix (p. 276). Each form has some advantages to recommend it, though it matters little which is adopted.

Form of the notes.

However carefully notes may be prepared, they are not necessarily to be followed rigidly in the giving of the lesson. Notes are made for the teacher, not the teacher for the notes, and if, in front of his class, he discovers that the children have a greater or a smaller knowledge of the subject than he gave them credit for, or that he has misjudged the difficulty of teaching any part, he should, as the lesson proceeds, adapt himself to the unexpected conditions. To do otherwise would be to pay tithe of mint and anise and cummin, but to neglect the weightier matters of the law.

Deviations from notes.

ILLUSTRATIONS

A teacher's character may, to a great extent, be inferred from the way in which he illustrates his lessons. If he lacks industry, he will either not illustrate them at all, or he will illustrate them with whatever chances to be available at the moment. If he lacks foresight, he will fail to provide some illustration that is absolutely necessary, or the illustrations that he provides will prove ineffective because some essential detail has been overlooked. If he lacks originality and ingenuity, his illustrations will be far-fetched, or they will be spiritless copies of something that he has seen or heard of. On the other hand, the teacher who is diligent, prescient, and ingenious foresees and provides all the

Illustrations an index to character.

illustrations needful, adapts to his needs whatever may be within reach, and ensures success by a careful attention to details.

Importance of illustrations.

It is hardly possible to lay too much stress on the importance of fully illustrating Object Lessons; for an Object Lesson that is not fully illustrated is a contradiction in terms and a foredoomed failure. The primary purpose of an Object Lesson is the cultivation of the perceptive powers, and this purpose is entirely defeated if the teacher does not offer materials for the exercise of the children's senses. An Object Lesson without illustrations is like a swimming lesson without water or a singing lesson without sound. The illustrations are not an ornamental fringe; they are the very warp and woof. Their function is not, like the pictures in our novels, to add to the interest and clearness of the story; rather, like the pictures of the ancient Mexicans, they are the story itself.

Kinds of illustrations.

1. Actual objects.

Where available, the best possible illustrations for an Object Lesson are actual objects. Pictures are worth having when nothing better can be had, but the illustrative value of the very best pictures is small compared with that of the things themselves. This is especially so in those very cases in which inexperienced teachers most frequently use pictures—that is, when the lessons are about animals. A picture of a cat, for instance, will not show the roughness of the tongue or its spoon-like action when lapping; it will not show the pads beneath the feet, or the projection and retraction of the claws; it will not show the sheaths that protect the claws, the arrangement of the fur, or the effect of light upon the pupils; all of which can be abundantly and easily demonstrated from a living specimen. Similarly, a picture of a fish would show the shape and position of gills and fins; but a gold-fish in a bowl, or even a sticklebat in

a jam-bottle, would show these even better, and would, in addition, show gills and fins at work.

Animals.

In order to illustrate lessons on animals in the way suggested, there is no need for the teacher to turn his school or his home into a menagerie. Many children keep pets, and would be pleased if the teacher were to borrow them for the purposes of a lesson. I have seen lessons on the Dog, the Cat, the Hen, the Rabbit, the Pigeon, and the Lizard illustrated with animals thus borrowed, and the most delighted member of a delighted class was the proud owner, who was allowed to stand in front and look after his own pet. Many animals not usually kept as pets may also be obtained with a little forethought. I have seen lessons on Rats and Mice, Snails and Slugs, the Frog, the Swallow, the Sparrow, and the Bat illustrated with living specimens caught by the teacher or his friends And animals that may be difficult to obtain alive may often be easy to obtain dead. I have seen dead Herrings, Mackerel, Crabs, Lobsters, and Oysters used with admirable effect; indeed, they were in some respects more useful dead than alive, for, as they were dead, the teacher was able to dissect them, and thus show their internal as well as their external structure. I have also seen lessons on animals illustrated with specimens stuffed or otherwise preserved. I remember, in particular, a most interesting lesson on the Crocodile illustrated with a small stuffed specimen which the teacher had borrowed from a friend who had brought it home from Egypt. I also remember effective lessons on Butterflies, Beetles, Humming-birds, and Serpents illustrated with preserved specimens.

Parts of animals.

It is obvious that there are many natural history lessons which cannot be illustrated with living or dead specimens. Some animals are too big, some are dangerous or disagreeable to handle, and many are impossible to

procure; and in these cases the teacher is compelled to fall back upon the best available substitutes. Where a whole animal cannot be used or cannot be procured, parts are useful, and with a little luck and some thought the school museum may be well stocked with these. The teacher's own dinners will furnish the shoulder-blade of a sheep, the head and limbs of a rabbit or hare, the heads, feet, and typical feathers of hens, ducks, geese, and turkeys, while, if he keeps his eyes open and has ordinary good fortune, he can pick up or procure the skulls or parts of the skulls of many common animals, and the heads of many common birds. Aided by these specimens, the teacher can give many valuable lessons on structure. Thus he can give lessons on bones, teeth, and feet generally; he can show the relation between the teeth and food of various mammals; and he can connect the beaks and feet of birds with their food and habits.

Plants.

Lessons on indigenous plants, too, should be illustrated with the actual things, and here, happily, there is no difficulty about obtaining specimens, as the build of roots, stems, bark, fibre, leaves, wood, seeds, and fruit can be abundantly demonstrated from material growing in profusion everywhere. Even in the case of foreign plants, the teacher is not entirely dependent upon pictures. Tea-leaves, for example, can be taken from the pot and pasted on white card; tobacco-leaves, cocoa and coffee berries, maize heads, cork bark, and many other vegetable substances can be obtained at the shops.

Manufactures.

Lessons on manufactures may often be illustrated with actual things. If the teacher himself lives, or if he has a friend living, in the district where any manufacture is carried on, he will be able to get specimens showing every stage from the raw material up to the manufactured article. If the school museum does not show the processes through which

wool, cotton, flax, iron, pens, pins, cork, and sundry other products pass, the teacher must be wanting in energy or luck.

Processes.

It greatly adds to the value of a lesson on a manufacture for the teacher to be able to imitate, no matter how roughly, the actions that he is describing. His descriptions will gain much in interest and in clearness, and will be far better remembered than if he trusted to words alone. I have seen the making of soap, paper, bricks, and pottery illustrated in this way. I have seen a hat pulled to pieces and re-made; a lock, a knife, and a clock put together, and a book bound in the presence of a class.

Illustrations must be seen.

Whatever may be the subject of the lesson, and whatever may be the specimens used to illustrate it, the children must see them, and, where the nature of the specimens permits, handle them also. An object held before the class appeals to only one sense, and, if small, appeals imperfectly to that. Even a crown-piece is not of much use to illustrate a lesson on coins; but if a penny were given out to every child the various stages in the minting would become quite clear. Lessons on leaves, flowers, the parts of a flower, seeds, and many other subjects should be similarly illustrated by letting every child have specimens—indeed, could not be properly illustrated in any other way.

School museum.

In speaking of illustrating by objects, I have assumed that the school has a museum. This need cost very little, because when a good dust-tight case with a glass front has been provided, the expense is practically over. Many useful things the teacher can furnish from his home stores; many animal and vegetable products can be obtained for the trouble of picking up or asking for; children and friends will become large contributors when once they are made to understand that illustrative objects and not curiosities are wanted; and most of the leading manufacturers, with a courtesy which

cannot be too gratefully acknowledged, are ready to furnish samples of their wares in every stage of production. In arranging his series of lessons the teacher will have the museum in mind, and now and then set a subject, not because it is essential that it should have a place in the series so much as because he has at hand abundant means of illustration.

The most effective illustration of a lesson is the actual thing spoken of; the least effective is a picture of it. Between the two come models, which, being only imitations, are not so effective as real objects; but which, being capable of examination from all sides, are more effective than pictures. In every good Kindergarten and infant school toys and other models are much used, but they are rarely seen in the senior departments. This is a pity, because even a rough model will add wonderfully to the clearness and interest of a lesson. A lesson on the Mountains and Rivers of a country, for instance, almost gives itself when the contours are shown in clay or plaster. No picture and no description can make the children understand the working of the common pump half so well or half so quickly as a model which can be constructed in half an hour out of glass tubing, and I have seen the working and internal structure of a steam-engine illustrated with a sectional model in cardboard, which did not take many minutes to prepare. In the best Continental schools lessons in natural history are always illustrated with life-like models, though I have never seen any used in England.

2. Models.

Though pictures are the least effective illustrations, they are by no means to be despised, and, where nothing better can be had, they are indispensable. The pictures in the market are often excellently adapted for their purpose, but the supply is not yet adequate.

3. Pictures

The characteristics of a good picture are three :—

1. It should be large enough to be seen by a whole class at

once. If a small picture is placed in front, only a few of the children can see it properly, and if it is carried through the class little good is done, because a clear conception cannot be formed from a brief glance.

Should be large;

2. A picture should be artistic, though artistic excellence should not be its chief or only recommendation. Its primary purpose is to illustrate lessons, and if it is not suitable for this, artistic merit will be an insufficient compensation. Some publishers, overlooking this elementary fact, have issued beautiful pictures which are poor illustrations. There is, for example, a series of heads of animals admirably drawn and printed, and well adapted for copies, but almost useless as illustrations; for how can a teacher give a complete lesson on an animal when all that he can show is a representation of its head?

Should be artistic;

3. Pictures of native subjects should be of native origin. It matters little to the English teacher, as teacher, whether his picture of a lion was produced in London, Paris, Berlin, or Vienna, but it matters very much where his picture of a cow is produced. He cannot and does not want to show every kind of cow; his purpose is best served by showing a typical English cow, but if he has a foreign picture he will be able to show only a typical French or German cow. The same remark applies to all domestic animals and to all familiar scenes, and yet one often sees, especially in infant schools, pictures of horses, cows, sheep, and dogs which are not exactly like anything that has ever come under the observation of the children—farmers with caps and curved pipes, carpenters with blouses and wooden shoes, and washerwomen with *battoirs*. The pictures, as pictures, may be excellent (though in many cases they are very much the reverse); but let their artistic merit be what it will, they are not of much use out of the countries in which they were

Should be of native origin.

produced, because elsewhere they offer few points of contact with the daily life of the children.

4. Black-board drawings. A drawing on the blackboard may often be used instead of or with printed pictures. Such a drawing has several advantages.

1. It awakens interest by being produced before the class.

2. It assists the attention and the memory by presenting only those details that the teacher wishes to emphasise.

3. It is always available.

4. It can be more easily copied by the children than an elaborate printed picture, and the act of copying will help to fix the lesson in the mind.

The blackboard drawing can be made to supplement the printed picture—

1. By showing the inside and the 'other side.'

2. By showing on a large scale parts of the picture too small to be seen by the whole class.

3. By showing successive stages in the growth or development of the object portrayed.

The use of coloured crayons will make blackboard pictures much more effective and much more interesting.

Every lesson that deals with even the elements of physical science should be amply illustrated with experiments. Children 5. Experiments must receive scientific facts, not on the authority of their teacher, but on the authority of their own senses, and if a direct appeal is not made to the senses, the lesson had better not be given. As has already been said, the object of science teaching is to foster the habit of observation and to store the mind with useful knowledge; and how can observation be fostered when there is nothing but a teacher and a blackboard for it to be exercised on, and how can the mind be stored with useful knowledge when words are made to take

the place of things? I have seen a lesson on the Composition of Air given without a single experiment; for any real good it did it might as well have been given in Greek. If the teacher had prepared jars of oxygen, nitrogen, and carbonic acid he could have made the children *see* the properties of each gas; he could have demonstrated that substances burn very rapidly in oxygen, and will not burn at all in nitrogen; he could have elicited the necessity for 'diluting' oxygen with nitrogen; he could have shown the proportion of the two gases in the air, and made clear that carbonic acid is a product of combustion (and of respiration).

All experiments should be carefully prepared, and delicate or difficult experiments rehearsed. Failure is often due to the neglect of some apparently trivial detail. I have seen a lesson on Oxygen entirely miss its mark because the teacher had forgotten to provide matches to light the substances that he had intended to burn in the gas. Similarly, I have seen a teacher who had to give a lesson on Magnets spend five minutes making in the presence of the class preparations which he should have made beforehand, and, after all, break down because he had no magnet. Teachers should consider that the failure of an experiment is a serious matter, because it may mean the failure of the lesson, and it must mean waste of time and loss of esteem.

Should be prepared

To prepare and to perform experiments is not all. I have known teachers prepare experiments carefully and perform them skilfully and yet do little good with them, for *an experiment is not necessarily an illustration.* Every experiment exemplifies some principle, but it does not illustrate the lesson unless the teacher makes perfectly clear *what the principle is*, and *how the experiment exemplifies it.* It is not enough, for instance, if a teacher wants to show the relative proportions of oxygen and nitrogen in the air, for him

And explained.

to say, 'A fifth of the atmosphere is oxygen and the remainder chiefly nitrogen,' and then perform the usual experiment of burning phosphorus under a bell-jar placed in water. He should, first of all, make clear, by a series of questions, that the jar, at the beginning, contains only air—that is, contains only oxygen and nitrogen. Then he should similarly make clear that the burning of the phosphorus exhausts the oxygen; that the phosphorus goes out before the whole of it is consumed because there is no more oxygen; that the water rises to take the place of the gas used up, and that therefore the height of the water is the measure of the oxygen and the space above is filled with nitrogen. So treated, the experiment would be an illustration as well as an experiment.

Experiments are not for amusement.

Young teachers sometimes seem to think that experiments are introduced merely to interest and amuse. I saw one teacher who had to give a lesson on the Pressure of the Air lecture for half an hour, and then spend ten minutes over a few poor experiments; and another, who had to give a lesson on Fusible Substances, perform all his experiments together at the end—apparently as an after-thought. Experiments do interest and amuse, and if they did nothing else they would be worth having; but, properly used, they do far more. They do even more than make the children understand—they make them discover. They should, therefore, be the foundation of the teaching, not an ornamental addition. The same remark applies to other illustrations.

LANGUAGE

In treating of the selection of matter, I referred to the abuse of technical terms. Inexperienced teachers seem to think that words of learned length and thundering sound are a necessary part of every Object Lesson. They introduce such words freely, strive hard to explain them, and delude themselves into a belief that they are teaching science when they are not even teaching the terminology of science, for the only way in which we can make children really understand words is to make them familiar with the things to which the words apply. I do not say that technical terms should never be employed, but I do say that they should be employed sparingly in Object Lessons. The proper time for them is when the definite study of science is undertaken; before that they should be employed only when their use obviates long circumlocutions, or when there are no short and simple names for the things denoted. To speak, as I heard a teacher speak in a lesson to young children on the Spider, of palpi and a cephalo-thorax is worse than useless—it is giving a stone for bread.

Technical terms.

A teacher's language may be entirely free from technical terms, and yet be almost unintelligible from its 'bookishness.' Only a long experience of children enables one to realise how narrow are the limits of their vocabulary. The limits vary, of course, with the character of the homes; but, even when the parents are educated, young children have not a large stock of words, whereas when the parents are uneducated the stock is very small indeed, and simplicity becomes doubly a duty. It has been stated that an illiterate hind can express the whole of what are called his ideas with 400 words. This

'Bookishness.'

number is probably under-estimated,[1] but there can be no doubt that uneducated people know the meanings of comparatively few words, and that their children know the meanings of still fewer. A teacher is, therefore, not likely to be understood when he speaks to such children of 'subjecting butter to the influence of heat,' of 'bringing a flame to bear on a fusible metal,' or of a reptile's tongue having 'an adhesive substance at its extremity,' and it should never be forgotten that if our pupils have to think about our words they cannot be thinking about our thoughts. A teacher's language should be transparent—not like a stained-glass window, which may in itself be worth study, but which obscures or excludes the surrounding world.

Purity.

A teacher should aim at speaking so as to be understood by all his pupils—if he does not want to be understood, why should he speak?—but to make his meaning clear he should never resort to mean colloquialisms, to slang, or to provincialisms. His language should be a model of purity as well as of simplicity, though it would be pedantry to set up as high a standard of style for speaking as for writing.

[1] An American writer, after a careful inquiry into the number of words used by various classes, comes to the following conclusions :—

'Every well-read man of fair ability will be able to define or understand 20,000 or 25,000 primitives and principal derivative words.

'The same man, in his conversation and writing, will use not less than 6,000 or 7,000 words. If he be a literary man he will command 2,000 or 3,000 more.

'Common people use from 2,000 to 4,000 words, according to their general intelligence and conversational power.

'An "illiterate man" (one who cannot read) will use from 1,500 to 2,500 words.

'A person who has not at command at least 1,000 words is an ignoramus, and will find difficulty in expressing his thoughts, if, indeed, he have any to express.'

QUESTIONS

A lecture differs from a lesson. Both the lecturer and the teacher strive to secure attention by the presentation of interesting facts or the interesting presentation of facts; but the lecturer looks upon his audience as a whole, while the teacher looks upon his as units. The lecturer does not hold himself responsible for all his hearers understanding or for any of them remembering what he says, but the teacher considers it his duty to make each hearer understand and remember. The lecturer makes statements, while the teacher mixes questions with statements; and what is meant for a lesson often is only a lecture, because few questions are asked.

Lecturing and teaching.

A teacher asks questions—

Purposes of questioning:—

1. To sound previous knowledge.

1. To find out what the children know, so that he may avoid waste of time in trying to teach what has been already learned, and may ascertain what is the foundation on which he can build.

2. To convince of ignorance.

2. To convince children of their ignorance, and thus awaken in them a desire for knowledge. In nearly every class there are a few children who have too high an opinion of their own attainments, and who, believing that the teacher has nothing new to tell them, are little disposed to listen. A few searching questions will, without destroying necessary self-respect and self-confidence, show these that they have yet much to learn.

3. To secure attention.

3. A teacher sometimes asks questions to secure attention. When children allow their minds to wander, nothing so promptly and thoroughly recalls them to the business in hand as a well-aimed question.

4. A teacher also asks questions to direct and encourage thought. It is important that children should be made to remember, still more important that they should be made to understand, and most important of all that they should be made to think. The second includes the first, because the better we understand a thing the easier we shall remember it; and the third includes the first and second, because if, with or without guidance, we think a thing out for ourselves, we shall both understand and remember it. It may be useful to remember such simple formulæ as $s = \frac{1}{2} ft^2$ or $\sin.^2 A + \cos.^2 A = 1$; we are the more likely to remember them the better we understand what they mean and how they are applied; we are certain to remember and understand them if we can go through the processes by which they are arrived at. The opportunities which different subjects of study afford for the cultivation of the thinking powers vary greatly; the degree to which different teachers avail themselves of those opportunities also vary greatly; and it may be safely asserted that that subject possesses the highest educative value which affords most opportunities for quickening thought, and that that teacher is the best educator who most fully avails himself of the opportunities afforded.

4. To direct thought.

Whatever may be the purpose for which questions are asked, certain general rules apply to them.

1. They should be clearly and concisely worded. Before beginning to speak, the teacher should form a perfectly definite idea of what he wants to ask, and then ask it in such a way that the pupils shall also form perfectly definite ideas. How could children be expected to follow the following question with which I heard a teacher introduce a lesson on Frogs: 'If any of you boys were to go into the country in the spring-time in the commencement of the year, and you go near a stream in the country, in some

Rules for questions: 1. Should be clearly worded.

parts you will almost be sure to see a lot of them (little things) jumping about and in the grass. What would they be?' What has been said generally about the language of lessons of course applies to the language of questions. 'What does a plant derive its life from?' is a concise question, perfectly clear—to those who understand it—but asked, as it was, to children of eight, it was unintelligible.

2. Questions should be definite enough to call forth the answer desired. "Why is this lamp burning?' 'What do we always find in the school-room in the day-time?' 'What are we always doing?' are types of questions likely to lead to much waste of time, because the teacher may get twenty correct answers before he gets that which he wants.

2. Should be definite.

3. It follows that questions should admit of only one correct answer. Such a question as 'What do you notice about this?' (some object presented to the class) may appear justifiable, nay commendable, because it requires an exercise of the children's own powers of observation, but there is a danger of its bringing answers which are irrelevant, or which cannot be used at that stage of the lesson. 'What do you notice about its weight, shape, colour, head, eyes, teeth, fur, &c.?' would have all the merits of the vaguer question and be free from its defect.

3. Should admit of only one answer.

4. Questions which admit of only two correct answers should not be asked. If I ask, 'Is this metal hard or soft?' 'Did Richard follow the advice of his father?' one of the two possible answers is, as a matter of chances, as likely to be correct as the other, and there is little incentive for children to think when the probability is so small of their being wrong if they do not think. Besides, when the wrong answer has been rejected, the right one can be given without any thought whatever.

4. Should not admit of only two answers.

5. It follows that no question which would encourage guessing should be asked. Guessing is encouraged directly by such questions as, 'What do you suppose the size of a cotton plant is?' 'Who thinks that it is six feet high?' 'Hands up boys who think cork will burn?' and it is encouraged indirectly by asking questions which the children cannot reasonably be expected to answer, such as, 'What is put on the land to make it rich again after the tobacco crop?'

5. Should not encourage guessing.

6. A question should not, as a rule, be asked on the substance of a statement immediately after the statement has been made. If children are told, 'Bricks are made of clay,' and at once asked, 'What are bricks made of?' they can give the right reply without thought. A question immediately after a statement may be necessary when a child has to be convicted of inattention, or when the subject is so very difficult that the teacher must make sure at every step that the children are following him.

6. Should not be asked immediately after statement.

7. Questions should be well distributed. Some teachers confine their questions to the children immediately in front of them, some to the bright, and some to the dull.

7. Should be well distributed.

8. Questions should not be repeated, as repetition on the part of the teacher invites inattention on the part of the scholar.

8. Should not be repeated.

A statement ending with an ellipsis to be filled up is a form of question requiring the least possible exertion from the pupils, and is, therefore, a form which should be employed only when there are sufficient reasons for making the work specially easy. The ellipsis, moreover, requires careful treatment. There ought to be but one way of filling up the blank correctly, and to find that way ought to require thought. 'Wheat grows in . . . ,' 'The motion of the earth on its axis

Ellipses.

causes day and . . . ,' and 'The molecules are kept together by the force of co- . . . ,' are all examples of bad ellipsis ; the first because the most thoughtful pupil might feel some doubt about the word desired, the second and third because the most thoughtless could feel no doubt whatever.

Some attention should be paid to the wording of the answers as well as of the questions. Answers that are too brief should never be accepted, even though correct in all but form. In the best Continental schools complete sentences are required in replies. This is a most valuable preparation for written composition, and though it may be pedantic to insist upon complete sentences always, there is no pedantry in objecting to such highly elliptical answers as the following : 'What happened to the wax when I held it above the flame?' [Liquid.] 'What is the meaning of *evergreen*?' [Always.]

Wording of answers.

An ungrammatical answer should never be accepted. Correctness of speech is much more a matter of habit than of rules. The children of educated parents speak correctly before ever hearing of grammar, whereas it is not rare to hear children who have been taught to parse and analyse very well speaking incorrectly. Every opportunity for assisting the formation of a good habit should therefore be seized, and an ungrammatical answer is perhaps the opportunity which occurs oftenest. Suppose such an answer as 'They was too old' to be correct in substance. The teacher should explain that it was right in fact, but wrong in form. The child who gave it might then detect the error ; if not, the teacher might proceed, 'You said, "They *was* too old ;" what ought you to have said?' There would have been no mention of grammar, and yet a valuable little lesson in grammar would have been given, for 'a child shall take more profit of two faults gently warned of than of four things rightly

Ungrammatical answers.

hit.'[1] The elder pupils could be made to see why the wording of an answer is wrong, but the teacher should not be tempted into digressions. He might make a note of the error, and use it as a text for the next grammar or composition lesson.

TELLING AND ELICITING

Jacotot. Jacotot, who maintained that a teacher should tell his pupils nothing, would be surprised and disappointed could he see how many teachers of the present day act as if it were their duty to tell their pupils everything. The precept of Jacotot was not altogether reasonable, and the practice of the teachers to whom I have referred is not altogether unreasonable. He forgot that we have to inform as well as educate; they forget that we have to educate as well as inform. If children acquire only such knowledge as they can discover, or be made to discover, for themselves, they must remain ignorant of very many things that it is necessary and useful for them to know; and they cannot enter into possession of the rich heritage of wisdom and experience bequeathed to them by the past, because if it is wrong for them to learn from a teacher it must also be wrong for them to learn from books. On the other hand, telling children too much allows their faculties to lie fallow, and their capability and god-like reason to fust in them unused.

Too much telling. Jacotot's precept must be modified before it can command universal acceptance: A teacher should tell his pupils nothing that he can make them find out for themselves in school without waste of time. Many things—all historical and most geographical facts, for instance—they must learn from books, which is only another form of telling;

[1] Roger Ascham.

still there can be no doubt that children are told much that they ought not to be. Their memories are stored, instead of their faculties being developed. They are exhorted to open their mouths and shut their eyes and see what good things the gods will send them, instead of being made to earn the good things by their own exertions.

The innumerable illustrations that might be given of needless telling divide themselves into two classes. Teachers tell

Illustrations.

what children could find out by the exercise either of their own senses or of their own reasoning powers. A teacher giving a lesson on Tobacco will tell his pupils that snuff is a fine brown powder, when, actually having some snuff, he could make them describe its qualities, presuming that they are worth dwelling upon; or, giving a lesson on a Coin, he will first tell them that it is composed of certain metals, and then tell that these metals are melted and mixed, when he could have made them infer the second fact from the first.

In dealing with the arrangement of the matter of a lesson, I spoke of the possibility of starting with one fact and then

Eliciting.

making children infer other facts from it. When, for example, a teacher has shown the situation of the British Isles he can elicit why the west coasts are indented; why the east wind is dry and cold and the south-west wind wet and warm; why more rain falls in Ireland than in England, and in Westmoreland than in Norfolk; why Liverpool is the port for the American trade and Lancashire the seat of the cotton manufacture; and why we are a nation of shopkeepers. In lessons on animals, again, the same process can be carried on to a great extent. The food of cats and horses can be deduced from their teeth; the digestive organs of a hen from its want of teeth; the teeth of a mouse from the fact that it can gnaw through boards; the speed of a greyhound from the animal's broad chest and long sinewy limbs; the aquatic habits

of a duck from its webbed feet, and the short legs of a swallow from its long wings; and no injustice would be done to a teacher if his skill and the educative value of his lessons were measured by his success in making children reason out conclusions from observed or stated facts.

Counterfeit eliciting.

One sometimes hears a kind of counterfeit eliciting, wherein the questions are directed, not to making children think, but to making them give a certain word. An infant-school teacher points to a letter and asks what it is. There being no answer she proceeds, 'What makes honey?' The child replies, 'A bee. Yes,' says the teacher, 'and this letter is B.' Another teacher shows some tallow and asks what it is. The children reply, 'Fat, lard, dripping.' Instead of making them smell it he says, 'What are candles made of?' and thus gets the word desired without any exercise of the children's senses or intelligence.

EMPHASIS

Crystallisation.

The process of crystallisation is full of suggestion to the teacher. A saturated solution of the substance to be crystallised is made and allowed to evaporate; threads are suspended in it, and around them the crystals form. In every lesson there should be threads. In a lesson on Winds, for instance, unless the children can be made fully to realise the fact that heated air rises they will gain nothing. When the teacher has, by illustration, explanation, and recapitulation, made the fact clear in all its bearings, till it has become a part of the children's working knowledge, he can proceed to show the application of it in the production of wind. Then, whatever may be forgotten, the leading principle will be remembered, and the children will be able to group the rest of the

lesson around it. The principle will be the thread on which the information crystallises.

One often finds in the lessons of inexperienced teachers an entire absence of threads. The fundamental facts are not emphasised, essentials and accidents are treated alike, with the result that children form no idea of the lesson as a whole, and perhaps remember an illustration but forget what principle it was intended to make clearer.

No emphasis.

Where emphasis is not entirely absent one sometimes finds it in the wrong place. The most important parts of the lesson are allowed to take care of themselves, while great stress is laid on something incidental. In a lesson on Coins, for example, the teacher was silent on the necessity of alloying gold and silver, but he gave the exact proportions of the metals in each kind of coin, wrote the numbers on the board, and had them repeated till the figures were learned by heart. He thus caused a great deal of time to be spent in labour which profited not, and the only comfort was that the children would soon forget what he had been at such pains to teach.

Wrong emphasis.

SUMMARY

A good blackboard summary of the lesson is a great aid to proper emphasis, because it calls attention to the leading, and only to the leading facts, which are otherwise likely to be lost sight of behind a mass of details. A good summary is also a great aid to the memory, because it appeals to the eye as well as to the ear, and enables a clear and comprehensive view of the whole lesson to be taken in at a glance.

Aid to emphasis.

What a summary should be.

A summary

(1) Should be methodically arranged and plainly written.

(2) Should be written little by little as the lesson proceeds, and not altogether at the end.

(3) Should, if the children are young, contain no hard words.

RECAPITULATION

A good summary is a valuable help to recapitulation, because it shows the parts on which most stress ought to be placed. Children cannot take in much at once—how much they can take in depends on the nature of the subject—but, whatever the subject may be, the teacher must, after proceeding a little way, pause to revise.

There must be revision.

Recapitulation

(1) Should come immediately after the enunciation and explanation of fundamental principles, because it is useless to go on building before ascertaining that the foundations have been well and truly laid.

(2) Should come at every natural break in the lesson.

(3) Should at the end of the lesson be twofold, first to deepen the impressions that have been made, and then (without the summary) to show whether the lesson has been effectively learned.

(4) Should be chiefly in the form of questions. To re-tell is almost useless, because the facts have lost the charm of novelty, and little mental effort is required merely to listen to them a second time.

PART II.

FULL TEACHING NOTES

OF

COURSES OF LESSONS

ON

ELEMENTARY SCIENCE

[If the following Lessons are given at the rate of one a week, and thoroughly revised from time to time, they will provide work for four years. They are intended for children from seven or eight to ten or eleven. Hence the book offers to the first four Standards in the Public Elementary Schools of Great Britain a course of Elementary Science leading up to the specific study of Mechanics, Physiology, Botany, Chemistry, and Physics.]

NOTES OF LESSONS

FIRST YEAR

A: Lessons on Common Properties

SOLVENTS AND SOLUTIONS

[Two lessons, the division being left to the discretion of the teacher.]

Evaporation.—Pour a little water into a watch-glass or evaporating-dish, and place over a Bunsen burner or spirit-lamp. When vapour begins to rise ask, '*What is this?*' Children will answer 'Steam,' and there is no need at present to bring in the terms *vapour* and *evaporation*. '*What was it before it was steam?*' '*What changed it into steam?*' Continue the evaporation till the water has entirely disappeared. Show the dry dish, and emphasise the fact that the heat has made the whole of the water pass away into steam.

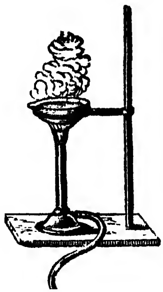


FIG. 1.

Solution.—Drop a lump of loaf sugar into a tumbler or test-tube containing clear water. Let the children watch the sugar dissolving. '*What has become of the sugar?*' The children will answer that it is melted. Say that *dissolved* is the word commonly used. '*Where is the sugar?*' '*How do you know that it is in the water?*' Let the water be tasted. Explain that the sugar has been divided into very little pieces which are mixed with every part of the water.

Recovery of solution.—'*How many things have I put into this glass?*' '*How can I separate the sugar from the water?*'

[Probably no answer.] '*If the water were driven away, what would be left in the glass?*' '*How did we drive away the water just now?*' Evaporate some of the solution, and let the children see and taste the sugar recovered. [To save time, and to obtain good results, the water should be saturated with sugar, and only a little of the solution evaporated.]

A saturated solution.—Into a small glass containing cold water drop finely powdered nitre (saltpetre), a little at a time, and stir with a glass rod. Make the children observe that the nitre is dissolved. Continue to add nitre till it begins to fall to the bottom of the glass. Thence bring out the general fact that water will dissolve only a certain quantity of a thing.

Hot water.—Pour some of the saturated solution into a beaker. Emphasise two facts: (1) That the water is cold; (2) That it will dissolve no more. Place the beaker above the burner or lamp. When the water is hot, add more nitre and stir. It is dissolved now. Thence bring out the general fact that hot water will often dissolve more of a thing than cold water.

Soluble and insoluble substances.—Provide a number of substances, and let the children discover by experiment which are soluble and which are insoluble in water. Make two lists on the blackboard. The soluble substances should include alum, sugar, and copper sulphate, and the insoluble sealing-wax, camphor, indiarubber, and fat.

Oil.—Half fill a test-tube with water. Pour some oil on the water. Shake, and show that the oil will not dissolve. To increase the difference in appearance between the two fluids, colour the water with red ink or an aniline dye.

Alcohol.—Sealing-wax was just now shown to be insoluble in water. The wax will dissolve in alcohol (methylated spirit). So with camphor. A pretty appearance will be obtained if a little water is dropped into the solution of camphor.

Benzine.—Fat (which would not dissolve in water) will dissolve in benzine. This is the reason why benzine is used to get grease spots off clothes. Illustrate with a greasy rag.

Naphtha.—Indiarubber (which would not dissolve in water) dissolves in naphtha. That is the way in which it is dissolved for mackintoshes and other waterproof articles.

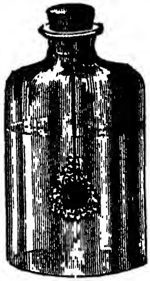


Fig. 2.

[*Preparation for the next lesson.*—In the saturated solution of copper sulphate (blue vitriol or bluestone) suspend in the presence of the class a small object (such as a stone), and say that you will let the solution stand till the next lesson. In the saturated solutions of alum, nitre, and sugar suspend pieces of string. Ask the children to do the same with a solution of alum, and to bring for the next lesson the strings with all that will be found clinging to them.]

CRYSTALS. SALT-MAKING

Crystals.—Ask how many children made solutions of alum as requested at the end of the last lesson. Examine the strings, and say that the bright little things clinging to them are called *crystals*.

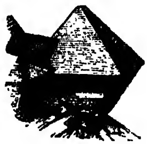


Fig. 3.—Crystals of alum.

Produce the solutions set aside from the last lesson, and let the children observe the crystals.

'*In what things sold by the grocer do we see crystals?*' [Sugar-candy, 'crystallised' sugar, and salt.] Show each.

Salt.—In some parts of the country men find on digging underground great rocks of salt. Show rock-salt. Also show some table-salt, and question out the differences between the two. Explain that the difference in colour is due to 'dirt' mixed with the salt.

'*Who has seen a spring?*' '*Where did the water come from?*' '*Suppose the water had touched some rock-salt, what would it do to the salt?*' Illustrate by dissolving some rock-salt, and say that salt springs are found in some parts of the country.

'How did we get the sugar out of the water last lesson?' 'How can men get the salt out of the water from salt springs?' Prepare a solution of salt. It need not be saturated. Evaporate *by a gentle heat.* If the solution is allowed to boil we shall have a shapeless mass instead of salt crystals.

To get clean salt out of rock-salt men dissolve the rock-salt, and then let the water pass off in steam. [The other processes can at present be ignored.]

SUSPENSION. POROSITY

Solution and suspension.—Drop a little copper sulphate (blue vitriol or bluestone) into a beaker containing clear water. When it has dissolved ask, *'What has become of the bluestone?' 'Can we see any of it?' 'Why not?' 'How can we see that it is mixed with the water?'*

Drop a piece of chalk into another beaker containing clear water. Make the children see that it is not dissolved. Take out the piece of chalk and drop in some powdered chalk. Mix well. *'Where is the chalk now?' 'Is it dissolved?'* Let the water stand, and make the children note that the chalk sinks to the bottom.

Go through the same process with some other insoluble powder, as coal, charcoal, flour.

'What became of the copper sulphate?' 'What became of the chalk?' Bring in the term *suspended* now.

Pour the solution of copper sulphate into the beaker containing the chalk. *'How many things are there now mixed with this water?' 'The bluestone is ——?' 'And the chalk is ——?'*

Filtration.—*'How did we separate the salt from the water in our last lesson?'* We will separate the chalk from the water in another way.

Inside a funnel (of glass, if possible) place a piece of filter-paper. Blotting-paper will answer the purpose. Filtering-paper is sold ready cut in circles. If blotting-paper is used that must be cut into circles. Fold the paper to form a semi-

circle. Fold again to form a quadrant, then open out so as to form a conical cup by taking three thicknesses of the paper

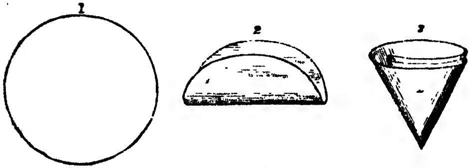


FIG. 4.

on one side and one thickness on the other. Place in the funnel. [A little water may be necessary to make the paper stick to the glass.] Pour the mixture very gently to avoid breaking the paper. [It is a good plan to let the mixture run slowly down a glass rod, the end of which nearly touches the paper.] The chalk remains on the paper, while clear water runs through.

Pores.—Elicit that the water could not have run through if there had been no holes in the paper. These holes are called *pores*, and the paper is said to be *porous*. Elicit also that the pores must be very small, or the grains of chalk would have passed through.

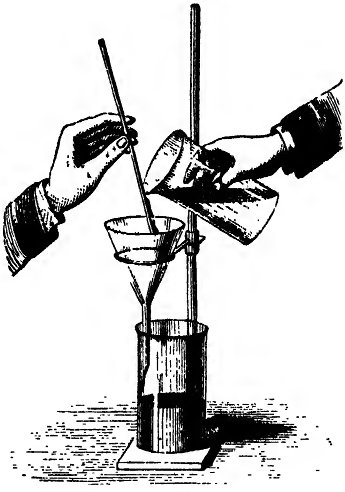


FIG. 5.

Produce a number of porous substances, such as sponge, bread, a piece of cane cut diagonally, lumps of sugar and salt, charcoal, sandstone, brick, blotting-paper, &c. Let the children examine them, beginning with the substances that have the largest pores. Ask the children to separate the substances that have pores from those that have none.

The sugar, salt, charcoal, sandstone, and brick will probably be placed in the second division. Show that these are porous also. Let the salt and the sugar stand in a saucer containing coloured water. In a very short time they will be coloured also. '*What has coloured these?*' '*Where did it come from?*' '*How did it pass through the salt and the sugar?*'

Treat charcoal in the same way.

Show that the brick and the sandstone are porous by dropping water on them.

Show that the blotting-paper is porous by making it absorb some ink.

FILTERS

The essential property of a filtering medium.—Repeat the filtering-paper experiment of the previous lesson, and elicit why the water passed through the paper while the chalk remained behind.

Take out the filtering-paper and put a piece of sponge (not too fine) in its place. The liquid passed through discoloured. '*How did the chalk pass?*' '*Why did it pass through the pores of the sponge and not through the pores of the paper?*' Mix sawdust with water, and pour on the sponge. '*Why did not the sawdust pass through?*' Emphasise the fact that if we want to filter we must use something which has very small pores.

A flower-pot filter.—Make a rough filter by placing a sponge above the hole of a flower-pot, with alternate layers of powdered charcoal and sand above that. Show its action by passing water discoloured with some powder (such as chalk, flour, or charcoal) through it.

A table-filter.—A table-filter, being of glass, is excellent for the teacher's purpose. Show its action. '*Where is the dirt which was in the water at first?*' Hence elicit that the charcoal (or other filtering medium) must be frequently cleaned.

Use of filters.—Bring this out by a few questions. Recall the distinction between *dissolved* and *suspended* taught in a

previous lesson. Pass through filtering-paper water with powdered chalk suspended and copper sulphate dissolved in it. Emphasise the fact that the filter keeps back only the suspended impurity.

Waterworks.—If there are any waterworks in the neighbourhood of the school, the children will be interested to learn that the filtering-beds do not differ in principle from the flower-pot filter made in their presence. The water passes first through a layer of sand two feet deep, then through four layers of gravel each six inches deep, the gravel increasing in size downwards. [This is for purposes of aëration, of which nothing need be said now.]

SUGAR

[Before the lesson let a solution of sugar stand so that crystals may be formed.]

Sugar-cane.—Sugar is made from the juice of the sugar-cane. The 'cane' is a kind of tall, thick, strong grass, which grows in very hot countries. Show picture, or draw one on the blackboard. The cane is full of pith inside. Illustrate pith by showing a fresh-cut piece of elder-wood. The pith is full of sweet juice (like the pulp of an orange).

Cutting.—When the canes are ripe they are cut down close to the ground, and taken to a mill.

Crushing.—There they are passed between large iron rollers. Compare to a mangle, or illustrate by two reels.

Boiling.—The juice is run into tanks and boiled. When mother is cooking she sometimes drops a little salt into the pan to make the scum rise. Lime is thrown into the boiling juice for the same purpose. The clear juice is then run off.

Make a solution of sugar. '*How can we get rid of some of this water?*' Illustrate. The clear juice is boiled in the same way till it becomes thick enough to form crystals on cooling. Show the sugar crystals prepared, and refer to the former lessons on Solutions and Crystals.

Molasses.—The juice (which has now become a thick mixture of sugar and molasses) is packed in casks having holes in

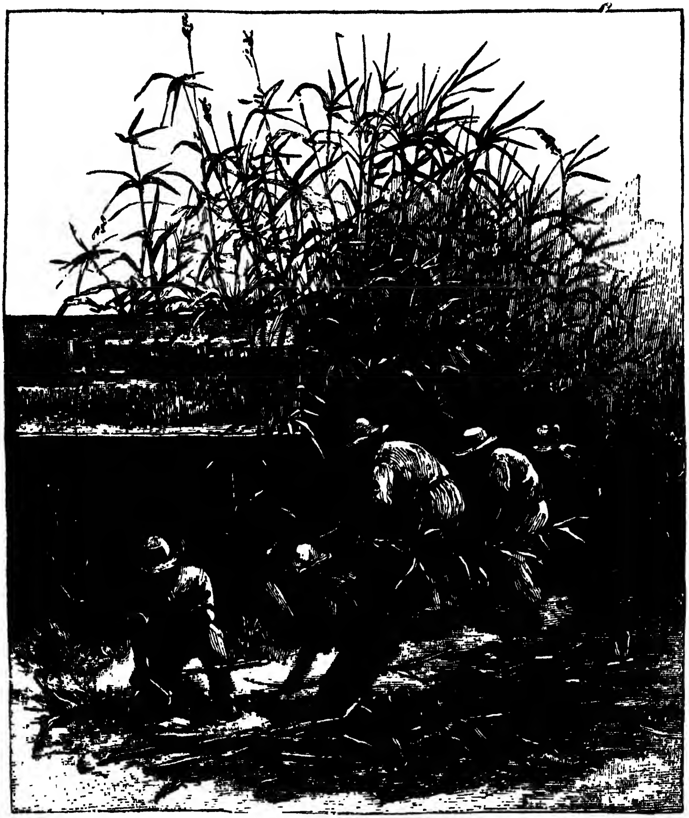


Fig. 6.—Cutting sugar-canes.

the bottom of them. '*What will run out?*' The molasses is used in making rum.

Refining.—The sugar is then sent to England in order to be made pure enough for use.

(1) It is first dissolved in warm water, a little lime is added.

and the mixture is filtered through thick folds of cloth. Illustrate. (Fig. 7.)

(2) The syrup is now clear, but it is still discoloured. To make it white it is filtered through animal charcoal (that is, charcoal made by heating bones in closed iron vessels). Illustrate the filtering.

FIG. 7.

(3) The sugar, which will form crystals, must now be separated from the syrup, which will not. Remind children of the experiment in a previous lesson, when salt crystals were obtained from a solution evaporated at a gentle heat. This is the way in which sugar crystals are obtained. Illustrate.

(4) The sugar is poured into moulds, formerly conical, now generally cubical. Illustrate on blackboard. The uncrystallised syrup is treacle. The moulds are placed point down, and the last remains of the molasses (now treacle) settle at the bottom. The discoloured point of the sugar-loaf is cut off. Ask about sugar-loaves seen in grocers' shops.

PLASTIC SUBSTANCES

Plaster of Paris.—Show dry plaster of Paris. Let the children handle it. Ask them to make it into a ball, flower-pot, tea-cup, &c. They cannot. Drop the powder into water, and knead the mixture into a paste. [Remember that plaster of Paris dries very quickly.] Let children again handle it, and again ask them to make the same things as before. Using a tea-cup, saucer, or small flower-pot as a mould, make a similar article. Turn it out or break the mould. Emphasise the fact that the plaster can be formed into almost any shape. The mouldings on the cornices and the ornaments on the ceilings of rooms are made out of plaster of Paris.

Sand.—By way of contrast moisten sand, and show that it cannot be moulded.

Clay.—Before the lesson thoroughly dry and powder some clay, and go through the same processes with the powder as with the plaster of Paris. Among other things mould two small bricks, and announce that for the next lesson one of them will be left to dry, and the other will be dried and burnt. Ask the children to burn some clay and bring it with them for the next lesson also.

Putty.—Similarly show that whiting cannot be moulded, but that mixed with linseed oil it forms putty, which can be moulded. Elicit, in passing, that putty would be of little use if it did not dry quickly, and then say that linseed oil is used because it dries quickly. [The litharge which is boiled with the linseed oil may be ignored.]

Gutta-percha.—Show that it cannot be moulded when cold; but that when plunged into boiling water it becomes soft, and can then be easily moulded. It is made into bags, bottles, shoe-soles, waterproof sheeting, &c.

Plastic.—'*The plaster of Paris, clay, putty, and gutta-percha were all alike in one thing; what was that?*' Things which can be moulded are said to be *plastic*. '*Name other plastic things.*'

BRICKS

Produce the two bricks made last lesson, one of which has been simply dried, and the other dried and burnt. '*Of what did we make these?*' '*Which is the harder?*' '*Why?*' Show a real brick. '*Of what is this made?*' '*Why is it hard?*'

Brick-making.—(1) Illustrate mould by a pencil-box without lid or bottom. Mould on a drawing- or other board. Show that clay will stick to the wood. '*What does mother sprinkle on her paste-board?*' '*Why?*' '*How shall we keep the clay from sticking to the board?*' Sprinkle sand on the board. '*How shall we keep the clay from sticking to the mould?*' Children will probably suggest sprinkling sand. Show that the sand falls off, and thence elicit that the mould must be damped

inside. Place mould on board, fill with clay, and smooth off superfluous clay with a ruler. Lift mould.

(2) Show that the brick if not handled very carefully would lose its shape. Hence elicit that bricks after being moulded must be left to harden a little.

(3) '*Who has seen a brick-field?*' '*Did you notice bricks drying?*' '*How were they placed?*' [In long, low walls with spaces between the bricks.] Get a child to place books similarly. '*Why are these spaces left?*' '*With what was the top of the wall covered?*' [Straw or boards.] '*Why?*' If the children cannot suggest the reason, sprinkle a little water on the dried brick from last lesson and repeat question.

(4) Burning is the next thing done. '*Where does mother bake her bread?*' [In an oven.] Bricks are sometimes baked in a kind of big oven called a *kiln*. More often they are placed in heaps. A layer is spread on the ground. [Illustrate again with books.] A mixture of small coal, cinders, and breeze (coke broken into little pieces) is strewn over. Another layer of bricks a little way apart. '*Why?*' More fuel, &c. A fire is lit, and when the fuel is burnt out the bricks are hard. Ready for use when cool.

Differences between clay and bricks.—(1) Let children feel that clay is soft and plastic, while the brick is hard.

(2) Pour water on both. It soaks into the brick, but not into the clay.

(3) Hammer both. Clay is tough, and the brick brittle.

Go through the same processes with some of the clay which the children themselves have burnt since the last lesson.

ELASTICITY

Elasticity by stretching.—Have a piece of what is familiarly known as 'elastic' measured. Stretch it; allow it to resume its original length, and have it measured again. '*What is this made of?*' [Indiarubber.] Emphasise the fact that the indiarubber gets back to its first size and shape.

Elasticity by pressure.—Show a hollow indiarubber ball.

Make children note the shape. Measure the circumference with a tape or piece of string. Squeeze the ball. Make the children see that the shape and size are altered. Allow the ball to resume its original size, and have it measured again. Emphasise as before.

Treat a ball of wool and a piece of sponge similarly.

By way of contrast show that a ball of putty or wet clay cannot be compressed, and will not resume its original shape.

Make the hollow indiarubber ball rebound from the table. Ask the children to notice whether there is any change in the shape of the ball when it strikes the table. They will see that it is flattened.

[1] Make a solid indiarubber ball similarly rebound from the table, and a glass marble, a clay or stone marble, and an ivory ball rebound off the hearth-stone, or (better still) off a slab of stone or marble placed on the table. The flattening in these cases will not be seen, but its effects can be made visible if a slab covered with some colouring matter be used. Show that when the ball is made only to touch it makes a small mark on the slab, but when made to rebound it makes a much larger mark, which is due to the flattening.

Fig. 8.

By way of contrast show that a ball of lead, putty, or wet clay will not rebound. It is flattened, and will not resume its shape. Emphasise the fact that in the other cases the ball gets back to its first shape and size.

Provide a bottle with a cork which will hardly go into the neck. Make the children see that the cork is too big. Then force it into the neck. Take it out, and make them see that it is again too big—it has gone back to its first size.

[1] If the children are dull or backward omit this paragraph.

Elasticity by bending.—Bend a piece of thin steel. Make children note that it goes back to its first shape. So with steel springs of various kinds.

Elasticity by twisting.—Get a piece of string with a small weight at the end. Twist; then hold by the free end, with the weight hanging down, and make the children see that the string goes back to its first shape.

The term.—Show 'elastic,' and ask what it is called. Anything which goes back to its first shape and size after being stretched, squeezed, bent, or twisted, is said to be *elastic.*

Degrees of elasticity.—We have seen that some things are very elastic and some are not elastic at all. Some things are a little elastic. Let the children divide the following articles into three classes, according to elasticity :—

(*a*) *Stretching.*—Indiarubber, cloth, leather, wire.

(*b*) *Pressure.*—Hollow indiarubber ball, solid indiarubber ball, marbles, ivory ball, clay, putty, sponge, cork.

(*c*) *Bending.*—Steel, tin, lead, a thin piece of wood, cane, whalebone, springs, a strip of glass, a lead pencil or penholder, a slate pencil.

(*d*) *Twisting.*—String, wire.

INDIARUBBER

What it is.—Indiarubber is got from the juice of some trees growing in the East Indies ['*India* rubber'], Brazil, and other hot places. Holes are bored in the roots, trunks, and branches of these trees, and tubes or little gutters are put in. A milky juice runs out, and is caught in pots. Illustrate by sketch on the blackboard.

When allowed to stand the milky juice separates into two parts—a thick, sticky part (which is the indiarubber), and a yellowish, watery part. Often this watery part is allowed to dry up, and the rest is sent to England. There it is passed through a machine full of spikes which tear it to pieces. It becomes

hot and soft, so that it can be worked like dough and thoroughly washed.

In some places when the juice has been got from the trees a lump of dry clay shaped like a pear is dipped into it and then held over a fire. '*What does the fire make the watery part do?*' A skin of indiarubber is left sticking to the clay. The dipping and drying are done over and over again till there is an inch or two of indiarubber sticking to the clay. Then the clay is broken out and the indiarubber is left. From its shape it is called *bottle rubber*. Show a piece.

FIG. 9.

Some properties and uses.—'*We saw in the last lesson that indiarubber was ——?*' [Elastic.] '*Name things in which it is used because it is elastic.*' [Braces, garters, bandages, elastic stockings, 'spring sides' of boots, &c.]

If stretched and kept in cold water for some time it becomes inelastic. Show a piece that has been stretched and kept in cold water for some days. It will regain its elasticity when warmed. Before being woven into braces, &c., the indiarubber is made inelastic by cold.

Show that indiarubber is waterproof.

Also that it is insoluble in water, but soluble in naphtha. Articles are made waterproof by having a solution of indiarubber spread over them. '*Name some things that are waterproof.*'

Vulcanite.—Indiarubber is 'vulcanised' by heating it with a small quantity of sulphur. Show vulcanised rubber. It is much more elastic than pure rubber, is not softened by hot water [hence made into hot-water bottles], and is not stiffened by cold.

Ebonite.—Show a comb or other article made of ebonite. This is indiarubber greatly heated with a large quantity of sulphur.

'Rubber.'—When we write with lead pencil we leave on the paper small grains of blacklead. When we rub these with indiarubber little pieces of the rubber are rolled off, and the little grains of blacklead stick to them.

B: Lessons on Common Animals

THE CAT

[Illustrations :—A cat or kitten, and a saucer of milk.]

Food.—Show cat. *'On what does this cat live?' 'If we did not give her any food, on what would she live?'* Emphasise the fact that cats catch their prey alive.

Feet.—Make children count claws on fore feet [five], and on hind feet [four], and make them observe that the former are longer and sharper than the latter. Elicit reason. *'With which claws does the cat catch a mouse?' 'Which claws have most weight on them when a cat is climbing a tree?'*

Each claw has a sheath of thick, hard skin. Let children see the sheath, and make the cat project and retract her claws. Elicit use. *'Why must the claws be sharp?' 'What would happen to them when the cat was walking if they had no sheath?'*

'Why do we cut our nails?' 'How does the cat cut her nails?' 'Who has seen a cat scratching a tree or chair?'

'What would a mouse do if she heard the cat coming?' 'What makes the cat able to move without making a noise?' Show pads under each toe and under the middle of each foot.

Teeth.—Show. Then elicit that the teeth are formed for tearing, not for chewing.

Tongue.—Let the cat lick a child's hand. To induce her to do so put a little milk on the hand. *'How does the tongue feel?'* Explain that the roughness is caused by little hooks fixed all over the tongue and pointing backwards. *'How does the cat get all the meat off a bone?'*

Let the cat lap some milk, and make the children observe the spoon-like action of the tongue.

'*How does the cat clean herself?*'

Eye.—Make the children observe that the pupil in a bright light is a narrow slit. '*What is the shape of the pupil at night?*' Compare admission of light through pupil to admission of light through window. '*Why do we pull down blinds when the sun is shining?*' '*Why does the cat's pupil become small in a bright light?*' '*Why do we pull up blinds towards evening?*' '*Why does the cat's pupil become large in a poor light?*'

Whiskers.—Make children touch the end. They will perceive that whiskers are stiff, and notice that the cat feels. '*Should we feel if the ends of our hair were touched?*' Elicit use of whiskers. '*Why does a blind man hold a stick before him?*' '*Why do we hold our hands out when walking across a room in the dark?*' '*When does the cat go about most?*'

Fur.—Make children feel that the fur is thick and warm, but not oily. Elicit that the cat is a night animal, and therefore needs a warm coat. '*Why does father oil his boots in rainy weather?*' '*Why does the cat dislike wet?*' '*Why does the duck like wet?*'

Habits.—Let the children say what they know about the habits of the cat.

THE DOG

[Illustrate by a living dog.]

Differences between cat and dog.—Cats see their prey, and catch it by creeping slily up to it. Dogs smell their prey, and catch it by running it down. Cats must therefore have good eyes and be able to move very softly, while dogs must have strong scent and be able to go fast and far. These differences will account for the differences in structure between cats and dogs.

Feet.—Make children count the claws on fore feet [five] and on hind feet [four]. '*What is the difference between a dog's claws and a cat's?*' [Dog's straighter and blunter.]

'Have you ever seen a dog chase a cat?' 'Where did the cat go to be out of the dog's reach?' [Tree.] *'Why did not the dog follow the cat?'*

'Have you ever seen a cat catch a mouse or a bird?' 'With what did she catch it?' [Claws.] *'Have you ever seen a dog catch anything?' 'With what did he catch it?'*

'Why, then, does the cat need claws sharper and more curved than the dog's?'

'What covers the cat's claws?' 'See whether the dog's claws are covered.' 'Why does the cat's claw need a sheath while the dog's has none?'

Make the children see that the dog cannot draw in his claws; also that his feet are not so softly padded as the cat's. *'Why does the cat need to go more softly than the dog?'*

Teeth.—Show. *'What are these sharp teeth used for?'* [Tearing.] *'Have you ever seen a dog eat a biscuit?' 'Could he tear a biscuit?'* Show action of the human jaw in grinding. Then show that the back teeth of the dog are capable of grinding. Make children see that the human jaw moves from side to side as well as up and down; then tell them that the jaws of cats and dogs can move only up and down.

Tongue.—*'How did the cat's tongue feel?'* [Rough and dry.] Make dog lick a child's hand. *'How does the dog's tongue feel?'* [Smooth and wet.]

Eye.—*'When does a cat catch most mice?'* [At night.] Her eye must therefore be made to see in a bad light. *'When does a dog catch things?'* [By day.] Question on the contrast and the reason.

Whiskers.—Recapitulate what was said about a cat's whiskers [p. 56]. Then elicit that as the dog is not a night animal, and does not have to pass through narrow holes, he does not want feelers. Then show dog's whiskers, and make the children observe that they are short and weak. Some dogs seem to have hardly any.

Hair.—*'With what is the cat covered?'* [Fur.] *'And the dog?'* [Hair.] Fur is the name given to the very fine, thick hair of certain animals. If a cat be examined carefully, 'over-hair' will be seen growing through the fur. *'Will*

water run more easily off hair or fur?' 'Who has seen a dog fond of the water?' 'And a cat?' 'Why do cats dislike water?'

Habits.—Let the children say what they know of the habits of dogs generally.

Blackboard summary.—Revise the lesson thoroughly, and place the heads of the comparison between cat and dog on the blackboard thus :—

	Cat	*Dog*
Prey . .	Sees, creeps	Smells, runs
Feet . . .	Claws sharp, curved	Claws blunter, straighter
	Sheath	No sheath
	Soft pads	Harder pads
Teeth . .	Tearing [1]	Tearing and grinding
Tongue . .	Rough, dry	Smooth, wet
Eye . .	Changes shape ; for dark	One shape ; for light
Whiskers .	Long and strong	Short and weak
Covering .	Fur	Hair

THE HORSE

[Illustrate by means of a good picture. If the teacher had, or could borrow, a horse's skull it would be of great advantage.]

Head.—Long ; rather broad at top ; nose narrow.

Teeth.—'*What does a horse eat?' 'What part of its food has a horse to cut?' 'And what part to grind or crush?' 'What kinds of teeth must it therefore have?' 'In what part of the mouth are the cutting teeth?' 'And the grinding teeth?'*

In front of each jaw the horse has six sharp, broad teeth for cutting.

A little way from these there is on each side and in each jaw a long, sharp tooth called a tusk.

'How many of you have played at horses?' 'How many have had the bit in your mouths?' 'Could you close your

[1] The fact to be brought out is that cats are more purely flesh-eaters than dogs ; the fact that even cats have teeth which naturalists call molars may be ignored.

mouths?' 'Why not?' Thence elicit that between the tusks and the grinding teeth there must in the mouth of the horse be a gap. This is called the 'bar,' and receives the bit.

Beyond the 'bar' come the grinding teeth.

'Could a horse eat flesh?' 'Why not?'

Neck.—Long. A horse not fed by man would live on grass alone. *'How could it reach the grass if it had a short neck?' 'Why, then, is a long neck useful?'*

Make children describe mane. *'When does your mother put a scarf round your neck?' 'Why does she put it?' 'What is the use of the mane to a horse?'*

Skin and hair.—Skin very thick; made into leather for soles. Hair short and fine; grows thicker in winter. *'Why?'* Sometimes clipped. *'Why?'* Elicit that if the horse be deprived by clipping of its natural covering an artificial covering should be provided.

Tail.—*'Could a fly hurt a dog or cat?' 'Why not?'* [Thick hair or fur.] *'What kind of hair has a horse?' 'Have you ever seen horses stung by insects?'*

'If a fly settled on your hand, how would you frighten it away?' 'How does the horse, which has no hand, drive away insects?' 'Is it kind to crop a horse's tail?'

Feet.—*'How many toes have you?' 'And a dog?' 'A cow?' 'A horse?'*

'With what is the horse's toe covered?' 'What is the use of the hoof?' 'Why is it shod?'

Elicit that the horse's hoof corresponds to our nails; that therefore it has no feeling; and that shoeing hurts a horse only when the nails are driven into the 'quick.'

Kinds.—Dwell on the work and corresponding structure of a few typical kinds, as

(1) The cart-horse, built for great strength, but not for swiftness.

(2) The race-horse, built for great swiftness, but not for strength.

(3) The hunter or carriage-horse; intermediate.

Habits.—Let children say what they know of habits.

THE COW

[Illustrate by good picture, blackboard sketch, and, if possible, a cow's skull.]

Where the cow lives.—'*Where does the cow mostly live?*' [In fields.] '*On what does she mostly feed?*'

Feet.—'*Will grass grow best in a dry field or a moist one?*' '*If you tried to walk on stilts through a moist field, what would the stilts do?*' [Sink in.] '*Would broad, soft shoes sink in?*'

Show picture of cow's foot; 'cloven.' Describe. Illustrate action by separating first and second from third and fourth fingers.

Teeth.—'*If you were in a field and wanted a handful of grass, how would you get it?*' [Cut it.] '*And if you had nothing with which to cut it?*' [Pluck it.] '*Could you by listening tell whether I was cutting or plucking grass?*'

'*How many children have been near a cow feeding in a field?*' '*Did she cut or pluck the grass?*' [Pluck it.]

Describe teeth, and, if possible, show skull. Front of lower jaw six broad cutting teeth. Front of upper jaw no teeth, but the gums form a kind of pad almost like indiarubber. No teeth like the horse's tusks. Twelve grinders in each jaw.

With her long tongue the cow brings the grass between the front teeth and the 'pad'; then she gives a jerk and the grass is torn off.

Chewing the cud.—'*Who has seen a cow biting her food when she was standing up and eating it?*' '*Who has seen a cow chewing when she was lying down and not eating?*' She was then chewing the cud.

Explain that lions, tigers, and other beasts of prey are very fond of cows. The grassy plains on which wild cows fed were exposed. It was therefore necessary that the feeding should be got over in a very short time. Cows therefore quickly swallowed all the food they wanted, and then retired to some safe place to digest it.

'*What do we do to food in our mouths?*' [Bite it.] '*And then?*' [Swallow it.] '*Where does it go then?*' [Into the

stomach.] There it is changed into a liquid. '*Could we bring the food back from our stomachs into our mouths?*'

The cow can. She has four stomachs. She swallows the food first; then brings it back, chews it, and swallows it again.

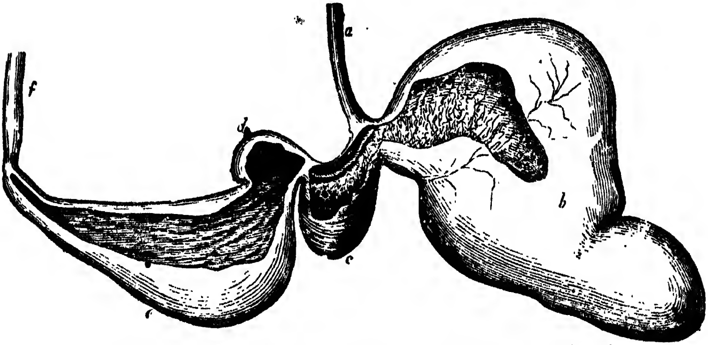


FIG. 10.—Stomach of cud-chewing animal [sheep]. *a*, œsophagus; *b*, paunch; *c*, honeycomb; *d*, manyplies; *e*, true digestive stomach; *f*, first part of intestine.

Neck.—Long. '*Why?*'

Horns.—Ask questions about means of defence of familiar animals. '*And of the cow?*'

Skin.—Thick and strong. '*Hence made into?*'

Hair.—Rather short. Can be pierced by insects. Cows much troubled by them in hot weather.

Tail.—'*How does she get rid of them?*' Tail long and tufted.

Uses.—Question about uses of cow alive and dead.

Blackboard summary.—Comparison between cow and horse :—

	Horse	*Cow*
Head .	No horns	Horns
Teeth .	Cutting teeth in both jaws	Cutting teeth in lower jaw only
	Tusks	No tusks
	Grinders	Grinders
Cud	Does not chew the cud	Chews the cud
Neck	Long	Long
	Mane	No mane
Feet	One toe	Two toes (cloven)
	Shod	Not shod
Tail	All hair	Tuft of hair

THE ASS

Comparison with the horse.—Show pictures of horse and ass, and ask in what way the two animals are alike, or nearly alike.

(1) Shape of head.

(2) Shape of legs.

(3) Feet. The ass's hoof is longer and narrower than the horse's. Hence the ass is very sure-footed, and is used to carry persons up mountains.

(4) The arrangement of the teeth is exactly the same in the two animals, though this cannot be seen from the picture. Question about the horse's teeth, and bring out the reason why a horse can have a bit. '*Do asses have bits?*' Then the ass's teeth must be like the horse's.

Refer again to the two pictures, and ask in what way the horse and the ass are unlike.

(1) Size.

(2) Colour. The horse may be black, grey, white, brown, or bay, or may have large spots of any one of these colours, but it never has stripes. The ass has stripes and is generally brown, or of a brownish-grey; a few are white, but black or bay asses are never seen.

(3) Ears.

(4) Tail. The horse's tail has long coarse straight hairs all over it; the ass's tail has a tuft at the end.

(5) Mane. The ass has very little.

(6) Hair. The ass's coat is thick and warm, so that the animal does not need a stable. It can stand wet and cold which would be too much for a horse.

(7) The ass is, for its size, stronger than a horse.

Food.—The ass does not require such good food as the horse. It will find enough to live on at the roadside and on commons, and will eat thistles and other herbs that the horse will not touch.

Habits.—The ass is generally considered stupid and obstinate, but naturally it is neither. Bring out by questions that

both these apparent qualities are the result of bad treatment, and show how asses should be treated. Then describe the qualities of asses in the East, where they are well treated.

THE SHEEP

Structure.—Show picture, and ask questions about the more obvious points in the structure of the animal, such as its size, the size and shape of the head, &c.

Legs.—The legs are thin but strong. Sheep living in meadows have large, fat bodies, and cannot run very fast, but mountain sheep are swift.

Feet.—Like a cow's, 'cloven.'

Teeth.—Also like a cow's. The sheep chews the cud. (Fig. 10.)

Neck.—The cow's neck is long. '*Why?*' '*What kind of neck has the sheep?*' '*Why does the sheep not want a long neck?*'

Tail.—'*What kind of tail has the sheep?*' The sheep's tail is not naturally so short as we generally see it, because lambs' tails are generally cropped. '*Of what use is the cow's tail to her?*' '*Why cannot flies sting sheep?*' '*Why do sheep not want long tails?*'

In one foreign country there is a sheep that has a long tail covered with fat, which people like very much, so a little two-wheeled cart is made for the tail to rest on.

Wool.—The sheep lives out-of-doors all the year round. '*What kind of covering does it need?*' '*What are our warmest clothes made of?*' '*When does the sheep need the warmest covering?*' In summer a wild sheep sheds its wool. Tame sheep would also shed theirs if it were not shorn off. Describe the washing and shearing.

'*Who has ever felt the wool on a sheep's back?*' '*What was it covered with?*' [Oil.] One would fancy that the sheep's wool would be soaked in the rain, but it is not. '*Why?*'

Horns.—Ask about the way in which various animals (e.g. the cow, horse, dog) defend themselves. '*How does the sheep defend itself?*' Most sheep have no means of defence, though

some rams have horns. Elicit the gentle, harmless nature of the sheep.

Habits.—Question, and where necessary tell, about the habits of the sheep, about shepherds, sheep dogs, &c.

Uses.—Question, and where necessary tell, about the uses of the various parts of the sheep—flesh, tallow, wool, skin. The skin of lambs is made into gloves (called 'kid') and into parchment.

THE PIG

Structure.—Show picture, and ask questions about the more obvious points in the structure of the animal, such as its size and shape.

Snout.—The nose is called a snout. It is long, pointed, and strong. Wild pigs live in forests and woods, and feed on acorns, beech nuts, and roots. The snout is used in digging these out of the ground when necessary.

Pigs would spoil the farmer's fields by digging them up. To keep them from doing this he puts iron rings into their snouts. The rings hurt when the pigs dig, but not at other times.

Pigs have a keen sense of smell, and are therefore used in France to find valuable roots called truffles.

Teeth.—A pig has teeth for cutting, tearing, and grinding. It can therefore eat almost any kind of food.

Boars, especially wild boars, have two large tusks.

Food.—'*On what do pigs feed?*' Question out that pigs will eat many refuse substances, and that valuable flesh is therefore obtained at a small cost.

Skin.—The skin is very strong and thick. It is made into saddles and strong purses.

Hair.—'*Who has seen a saddle?*' '*Who has noticed little holes in it?*' A bristle grew in each of these holes.

Pigs have no hair, but all have bristles—some more, some less. These bristles are made into paint-brushes, and are used by shoemakers.

Tail.—The tail is very short and often curly. '*Of what*

use are the tails of cows and horses to them?' 'What kind of skin have pigs?' 'Why do they not need long tails?'

Feet.—The feet of the pig are cloven. '*Name other animals with cloven feet?' 'How many of these animals chew the cud?' 'Does the pig chew the cud?'* The Jews were allowed to eat the flesh of any animal that had cloven feet and chewed the cud. '*Were they allowed to eat pigs?'*

Flesh.—The flesh of the pig when fresh is called pork. When smoked or otherwise 'cured' it is called bacon. The inside fat is called lard.

Habits.—Question about the habits, and show that the pig is not naturally so dirty, greedy, and stupid as is often supposed.

THE MOUSE

[Illustrate by a dead mouse. A living one in a trap would also be useful.]

Some habits.—Question on the habits of the mouse, and emphasise the following facts:—

(1) It gnaws through boards.

(2) Eats cheese, tallow, fat, &c., but nothing that needs tearing.

(3) Passes through holes.

(4) Is out by night.

Teeth.—'*How would a carpenter make a square hole in a piece of wood?'* [With a chisel.] '*How does a mouse make a hole in wood?'* [With its teeth.] Then the mouse must have teeth like chisels. '*And where must these teeth be?'* Show the two chisel-like teeth in the front of each jaw. These grow as fast as they are worn out. They are hard in front and soft behind, and this keeps the edges chisel-like.

'*With what do the cat and dog tear flesh?'* [With their pointed teeth.] '*Where are these teeth?'* Show that the mouse has no teeth for tearing.

'*What kind of teeth are there at the back of the mouse's mouth?'* [Flat.] '*What are they for?'* [Grinding.] '*Name*

other animals with grinding teeth?' Mice, therefore, cut food with their front teeth, and grind it with their back teeth.

Claws.—Show claws. They are small and sharp, so that a mouse can climb anything rough. *'Who has seen a mouse climb?'*

Whiskers.—*'We had a lesson some time ago on an animal with whiskers. What animal was that?'* [The cat.] *'And what did we say those whiskers were for?'* [To feel.] Show the mouse's whiskers. *'The mouse has to pass through ——?'* [Holes.] *'Why does it want whiskers?'*

Ears.—*'What animal is always trying to catch mice?'* Hence elicit that the mouse must be very watchful and hear the slightest sound. Large ears.

Eyes.—Elicit similarly that the eyes must be large and bright, especially as the mouse goes about by night.

Nose.—*'Has there ever been a mouse in your pantry?' 'What did it eat?' 'How did the mouse know that it was there?'* Hence elicit large pointed nose and keen sense of smell.

Legs.—From the small holes through which mice pass elicit short legs.

Fur.—Goes about by night. Hence elicit that fur must be warm and of a dull colour.

Habits.—Ask a few questions about these.

THE HEN

[Illustrate by good picture or by living bird. If the legs were lightly tied together the bird would be quite still. If nothing better can be procured the feet of a fowl would be useful.]

Food.—Ask on what the hen feeds. Make clear that her food is either pecked up or scratched out of the ground. Thence elicit the kind of beak and claws she must have.

Beak.—Show or draw picture. Compare with a duck's bill.

Feet.—Three toes in front, a little joined. One small toe higher, behind.

'How do birds lay hold of branches?' *'Have you ever seen a hen on a branch?'* Thence elicit that the hen has small grasping power in her claws. She can perch well because her body is well-balanced. To show this make a child stand first on one foot, then on both, wide apart.

Digestion.—*'What is the use of our teeth?'* *'How many teeth has the hen?'* [None.] Thence elicit that the food is

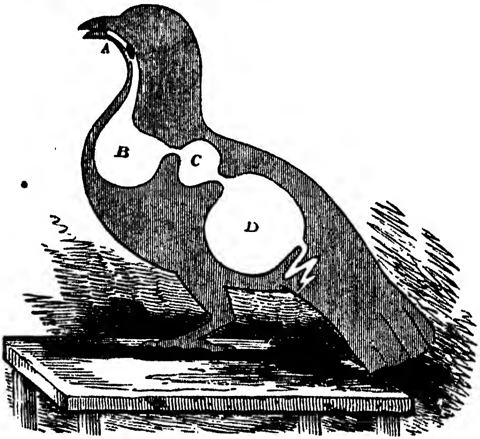


FIG. 11.—A, gullet; B, crop; C, second stomach; D, gizzard.

swallowed whole. *'Where does it go first?'* [To the crop or craw.] Show in sketch, or let child feel in living bird. Food stays there for some time and gets well moistened. *'Why does mother soak baby's biscuit?'* *'What does the moisture do to the food in the crop?'*

Food passes from the crop through the second stomach (where it is still further moistened) to the gizzard. This is a bag made of a very strong kind of skin. Illustrate action with the palms of the hands. *'Who has seen a hen swallow stones?'* These pass into the gizzard. *'Of what use are they there?'* *'Why is gravel scattered for fowls?'*

Covering.—Warm. *'Why do we have quilts on our beds?'* *'Of what are the warmest quilts made?'* [Down—the softest feathers.]

'Who has seen a hen out in the rain?' 'And a duck?' 'Why did the duck look happy and the hen miserable?' [Water runs off the duck's feathers, but settles in the hen's.]

Wings.—Of not much use for flying. *'Why?' 'Use?'*

Hatching.—*'What does the hen lay?' 'What sometimes comes out of the eggs?' 'What must the hen do to them first?'* Give details of hatching, and make the children say what they have noticed about a hen and chickens.

THE DUCK

[This lesson would be best illustrated by a live duck, which cannot be difficult to procure. If a duck cannot be procured have a good picture, also a foot and bill, and for comparison the foot and beak of a hen.]

A water bird.—*'Who has seen a duck?' 'Where did you see it?' 'Where do you most often see ducks?'* The duck is made to live a great deal in the water.

Food.—Slugs, worms, little creatures living in the water, and the soft stalks of plants.

Feet.—Show feet of hen and duck. *'What is the difference?' 'What is this skin called?' 'So the foot is said to be ——?'* [Webbed.] *'With what does the duck move itself in the water?'* It pushes against the water with its webbed feet. *'How many of you can swim?' 'How do you hold your fingers when swimming?'* [Close together.] Compare webbed foot to open hand with fingers close together, and another foot to hand with fingers spread.

Legs.—Compare position of legs with those of hen or other non-aquatic bird. The duck's body is long and heavy. The position of the legs enables the bird to swim well. *'How does the duck walk?'* [It waddles.] Ask a child to illustrate. *'Why does the duck waddle?'*

Feathers.—Show. Make the children see that the feathers are close, thick, and warm. Show down. *'What are the warmest quilts made of?'* [Eider down.] This is the down

of the eider duck. '*Where does the duck live?*' '*Why does it need a warm covering?*' '*What does father do to his boots when he wants to keep out the wet?*' [He covers them with oil.] The feathers of the duck are covered with oil. '*Who has seen a duck and a hen in the rain?*' '*Why did the hen look miserable and the duck happy?*' '*Who has seen a duck pecking at its feathers?*' It does this to break little bags which have oil in them.

Bill.—Show beak of hen and bill of duck. The hen picks up grains from the ground. The duck sucks its food out of the mud, so it has a large spoon-like bill, with a sort of comb on each side through which the bird strains out the water and mud.

Hatching.—Ducks are good sitters, but neglect the little ones as soon as they are out of the egg. Broods of ducks are therefore generally given to hens.

C: Lessons on Plants

CORN

[(1) In North America the word *corn* is applied specifically to maize (or Indian corn). In the British Isles the word is applied generally to the cereals most commonly grown—wheat, barley, and oats.

(2) To children of seven or eight living in rural districts this lesson will convey no information, and in their case a lesson on some other subject should be substituted.

(3) The lesson should be illustrated by the ear, grain, and flour of wheat, barley, and oats.]

Wheat.—The different kinds of wheat may be divided into two classes, autumn-sown and spring-sown. Elicit that as the autumn-sown must stand the cold of winter, it is the more hardy. There are two common kinds of autumn-sown wheat —red and white. Both are beardless. The white makes the better flour, but the red is more suitable for cold, heavy soils.

Spring-sown wheat is more delicate. The grain is bearded,

and smaller than that of the other class. It is most often sown when the autumn crop has failed.

Wheat grows to a greater height than barley or oats. The straw, when ripe, is yellow. The grain is short and rounded.

Wheat is used for human food, being ground into flour which is made into bread, &c.

Barley.—In an ear of wheat the grains are arranged round the stalk; in an ear of barley they are arranged in two rows, one on each side of the stalk. Barley is always bearded.

The straw is paler in colour than wheat, and not so tall. The grain is also paler and longer.

Barley is chiefly used for making malt. Show malt, and explain what it is made into. Barley is also used as food for horses, cattle, and pigs, and in some country districts the very poor make bread of it.

Oats.—If grown (as it often is) on a poor soil the straw of oats is short; on a good soil it is as tall as that of barley or even of wheat.

The ear is entirely different. It looks feathery, as each grain grows on a slender, drooping stalk.

The grain is longer and thinner than either wheat or barley. It is either white or black.

Oatmeal is very nourishing, and, in the form of cakes and porridge, it is much eaten in Scotland and in the north of England. Elsewhere it is largely used as food for horses.

Cultivation.—[Only the essential features need be described. The differences between the modes of cultivating the three grains may be ignored.]

(1) *Ploughing.*—'*What is the first thing to be done if you want to grow anything in your garden?*' '*And with what do you dig the ground?*' '*If you had to dig many large fields, why would you not use a spade?*' Show model or picture of a plough, and explain how the implement acts.

(2) *Harrowing.*—'*With what do you break the lumps and smooth the ground when digging in the garden?*' Elicit, as in the case of the plough, that a rake would not do for large fields. Then show model or picture of a harrow, and explain the action.

(3) *Rolling*, if necessary, to break hard lumps.

(4) *Sowing.*—Either broadcast with the hand [Illustrate], or in drills with a machine. Show picture and describe.

(5) *Weeding*, if necessary. Why done. When.

(6) *Reaping.*—Show models or pictures of scythe and sickle.

(7) *Binding.*—Explain and illustrate. On large farms the reaping and binding are now generally performed at one operation by a machine.

(8) *Carting.*

Threshing.—Explain what this is and how the process is performed. Illustrate the effect by rubbing an ear of corn. Call special attention to the mixture of grain and husks.

Winnowing.—Ask how you could get rid of the husks in your hand. Blow them away, and show that only the grains remain. On a large scale the blowing away of the husks is done by fans turning round in a winnowing machine.

Grinding.—Briefly describe.

RICE

Where grown.—'*Where do we buy rice?*' '*Who has seen it growing?*' It does not grow in this country. It grows in India, China, Egypt, the south of Europe, and the south of North America. Make the children realise that all these places are hot. Rice wants much water as well as heat; hence it is grown in swampy places and where the fields can be flooded.

Appearance.—Rice, when ripe, looks very much like barley.

Cultivation.—The land is first covered with water till it is quite soft and muddy. The water is then drawn off, and the seed is sown broadcast or in drills. The land is again flooded till the seeds sprout. The flooding is renewed when the plants are about 3 inches high, and again when they are nearly ripe. Great care is taken to destroy weeds and hurtful insects.

Harvesting.—When the grain is ripe the water is drawn

off and harvesting begins. Labourers (who sink in the soft soil) cut down the crop with sickles.

Paddy.—The grain is removed from the ears in various ways, which correspond to our threshing. Each grain is covered with a brown husk. Cut grains of wheat, and show that they too are so covered. The removed husk is the bran. The husk-covered rice is called 'paddy.' The paddy is passed between mill-stones, which take away the husk without crushing the grain.

Uses.—The children are familiar with the use of rice as a food, but they probably do not know that a larger number of people live on it than on any other article of diet. The natives of India and China eat little else. At the same time, rice is not very nourishing, and the inhabitants of cold countries could scarcely live on it alone.

Rice is also used for making starch. Place some ground rice in a muslin bag, and press between the fingers in a glass of water. The water becomes milky. Produce the same effect with starch in another glass of water.

MAIZE

Where grown.—Maize is also called 'Indian corn,' because it was the only grain grown by the Indians before America was discovered. It requires a climate 'with a summer four and a half to seven months long, without frost, the middle portion hot both day and night, sunny skies, sufficient rains to supply the demands of a rapidly growing and luxuriant crop, falling at such intervals as to best provide sufficient moisture without ever making the soil actually wet.'[1] Show an ear of maize in order to let the children see what a productive crop it is. On this account the cultivation was introduced into those parts of the Old World where the climate is suitable, such as Portugal, North Italy, Roumania and the neighbouring parts of Russia, and parts of Asia and Africa.

[1] *Tenth Census of the United States*: Statistics of Agriculture, Cereals, p 92.

Appearance.—Maize differs entirely in appearance from wheat, barley, and oats. The stalk is from 7 to 10 feet high, strong, jointed and reedy, and covered with leaves. [Ears may be obtained from a corn-chandler, and a few grains planted in a garden will produce stalk, leaves, 'tassel,' &c.] On the top of the stem grows a bunch of flowers called the 'tassel,' and lower down are about three ears. These are enclosed in a sheath of leaves, and consist of a stem called the 'cob,' with the grains arranged in rows as if closely stuck all round it. A long silky thread grows from each ear and comes out at the top of the sheath. These and the tassel fall off in time.

Cultivation.—Maize is sown late in the spring so that there may be no fear of the young plants being injured by frost. Before being sown the seeds are soaked to soften the skin. Show seeds to let the children see how hard they are. They are then planted in holes about 3 feet apart. When they have sprung up they are, if necessary, thinned out. The ground is hoed to destroy weeds, and the soil is heaped up around the roots to give them more food. When the crop is ripe the stalks are cut down and the ears twisted off.

Uses.—In the British Isles maize is not much used as food, except in the form of 'corn-flour,' but a good deal of 'Indian meal' is given to cattle, pigs, and fowls. In the United States it is used in many ways. The green unripe heads are a favourite vegetable, the grains being eaten with meat (like peas in England), and a preparation known as hominy (a kind of pudding made from coarsely ground maize meal) is also much liked. In Mexico maize is the principal food of the people. It is also much eaten in North Italy and in Roumania.

SOME EDIBLE ROOTS

Carrot.—Show. Ask what part of the plant it is. Roots shaped like that are called *tap-roots*. '*Why?*' '*Name others?*' [Turnip, parsnip, radish.]

Cut the carrot across. Show that it consists of two parts :

outer softer and sweeter than the inner and of a darker colour. Let the children say what the colour of each is. The inner part is 'woody.' From the top of it spring the leaves.

Used as food for man, also for horses and cattle. Sugar has been made from it.

Parsnip.—Belongs to the same order as the carrot. Compare the two in shape, size, and structure.

The parsnip is more hardy than the carrot, and may therefore be left in the ground all through the winter.

Turnip.—Two common kinds are grown—the 'turnip' and the 'swede.' Compare the two for shape, colour, and taste. Grown in fields. Seed sown in drills. Thinned with a hoe.

Used for flavouring soups, &c. Also eaten with meat (especially boiled mutton), but chiefly cultivated as winter food for sheep and cattle.

Radish.—Belongs to the same order as the turnip. As in the turnip, two common shapes. Show both, and compare with the turnip in size, colour, &c.

Generally eaten raw in salads.

[When the children see that the lesson is on roots used for food they will expect the potato to be included; but though this is popularly known as a root, it is really the tuber growing on an underground stem. (See p. 231.)]

SOME EDIBLE 'VEGETABLES'

Potato.—Show. '*What part of the plant is it?*' Children will probably say it is a root. Explain what part of the plant it is. The buds which it gives off in the form of eyes [Show] prove that it is not a root.

Planted in the spring. When the ground has been dug each potato is cut into pieces, each piece containing an 'eye.' Planted in rows. When the shoots are 3 or 4 inches high they are earthed up. The flower is white or purple. When the leaves begin to wither the tubers may be dug.

The potato is a native of America. There is much uncertainty as to when it was introduced into Europe, but it is

believed to have been grown first in Italy and then in Spain. [The statement that Sir Walter Raleigh brought it to Ireland in 1586 will not bear examination.]

Pea.—Two classes grown in Britain—garden and field. The garden pea generally climbs on 'sticks' placed for the purpose, and has red or white flowers arranged two or three on a stalk. The field pea is not 'sticked,' and has red flowers, only one on each stalk. The garden pea is grown as food for man, the field as food for horses and cattle. Describe mode of cultivation.

Bean.—Compare with the pea as to size, shape, stalk, and flower. [The flowers of the bean are white, with a black spot in the middle of each 'wing.'] When green, beans are boiled and eaten by man, but dry beans are chiefly used as food for horses.

French beans and scarlet runners.—The French or kidney bean and the scarlet runner [Reason for each name] belong to the same order as the common bean. Compare with it. They are not allowed to ripen, the pods being boiled and eaten when green.

The 'haricot bean' is the seed of a plant much like the French bean and scarlet runner.

Onion.—Is the *bulb* of a plant. Show roots. Cut to show structure. It is very nourishing, but has a strong smell and pungent taste.

COCOA

Cocoa and cocoa-nut.—Cocoa and the cocoa nut grow on two trees entirely different. The cocoa nut is the fruit of a palm; the cocoa bean (of which cocoa and chocolate are made) is the seed contained in the fruit of a tree something like a cherry tree. The proper name is cacao.[1]

Where grown.—The cocoa tree grows best in countries

[1] The botanical name is *theobroma cacao. Theobroma* means 'food for the gods.'

which are very hot and moist—such as Ecuador, Trinidad, Venezuela (Caracas), and Northern Brazil.

The tree.—The tree is from 15 feet to 20 feet high. Make concrete. Its trunk is straight and slender. The leaves are much like those of a cherry tree. The flower is of a reddish-yellow and without scent. The pod resembles a cucumber in shape and size, and, when unripe, in colour also. When ripe it is red. It contains from thirty to a hundred seeds something like almonds. These are the cocoa beans.

Cultivation.—The ground being thoroughly cleared of all weeds and stumps, the best and largest beans are thrown into water. Those that float are useless. Those that sink are kept in the water till they sprout. They are then planted in holes about 20 feet apart. As they grow they must be protected from the sun. The tree is at its best when about eight years old.

Gathering.—The fruit is ripe when the beans rattle in the pod. It is gathered twice a year, the gathering being done by hand.

Preparation.—After being taken out of the pods the beans are buried under a heap of green leaves. This soon becomes so hot that the hand cannot be held in it, and the beans ferment. The fermentation takes away a bitter taste from the beans and keeps them from growing musty. After being fermented the beans are roasted, and then bruised to loosen the skins. When these have been removed by fanning we have the 'cocoa nibs' sold in the shops.

The beans are very oily, and when ground make a kind of paste. When this has first been allowed to harden and then been cut into thin slices it forms flaked cocoa.

The oil is hard to digest, so it is removed when the best 'soluble' cocoas are made.

The oil is made into cocoa butter, which may be kept for any length of time without going bad.

Cocoa made into a paste, with sugar and some flavouring added, becomes chocolate.

COFFEE

[There ought to be no difficulty in procuring unroasted and roasted coffee 'beans' and ground coffee to illustrate this lesson. There may be some difficulty in getting a good picture of the tree.]

What it is.—Coffee is a part of the berry or fruit of a tree.

Where grown.—This tree grew first in Abyssinia. Then it was grown in Arabia and Persia, and now it is grown in most hot countries where the soil is suitable—such as Jamaica, Brazil, Ceylon, Java, Sumatra, &c.

The tree.—The tree is an evergreen, with leaves much like those of the laurel. If allowed to grow it would be as big as a large apple tree (about 20 feet high), but it is kept at a height of 6 or 8 feet. The flower is of a beautiful white, with a strong, sweet smell.

The berry.—When the flowers fade the berries come in their place. Each berry, when ripe, is about the size and nearly the colour of a cherry. After removing the fleshy outside we come to a kind of skin, inside which are two 'beans' face to face. Show. The beans are on one side flat with a deep ridge, and on the other side curved.

Gathering and preparation.—When ripe, the fruit is gathered, or shaken on cloths spread under the trees. The berries are passed between rollers which are close enough together to crush the fleshy part, but not close enough to crush the beans.

After being crushed the pulp is washed away, and the berries, still in their skin, are set to dry in the sun.

When dry they are passed between rollers which break the skin. The broken skin is blown away, and the beans are sorted and packed.

Roasting.—Show unroasted beans and roasted. Ask for the difference in appearance, taste, and smell. The unroasted beans are greenish in colour, and almost wanting in the peculiar taste and smell of coffee. They are roasted by being placed in an iron vessel which is turned round ['*Why?*'] over a fire.

The roasting should take place as short a time as possible *before the coffee is* wanted.

Grinding.—This also applies to the grinding. Describe the grinding.

ORANGES AND LEMONS

Orange.—*Where grown.*—The orange is believed to be a native of China, but it is now grown in all parts of the world having a suitable climate. Those imported to Britain come mostly from Spain, Malta, St. Michael (in the Azores) and Italy. The United States grow a large number in Florida and California, and also import many from the West Indies.

Kinds.—The most important are the mandarin or China orange, the Maltese, the St. Michael's, and the blood orange. [‘*Why so called?*’] The Seville orange has a bitter taste, and is therefore not eaten like other oranges, but it is very useful. From its flowers we get orange-flower water and an oil employed in making eau de Cologne, while the rind is cut up for marmalade.

The tree.—The orange tree is small. It has dark-green leaves dotted over with little points filled with oil. Most of the children have seen the pretty white flower in the ‘orange blossoms’ worn by brides. When ripe the oranges are gathered, wrapped in maize leaves, and packed in boxes.

Lemon.—Compare the orange and the lemon. They belong to the same family of plants. The lemon is a native of the north of India, whence it was introduced to the south of Europe. Many of those imported into Britain come from Italy, Spain, and Portugal. Lemon juice is made into citric acid, which is much used in the preparation of effervescing beverages. The peel is used fresh in confectionery, &c., and candied it is used in puddings.

Lime.—The lime belongs to the same family. It is grown for its juice.

MUSTARD

Where grown.—Mustard grows wild in nearly every part of the British Isles, but it is cultivated chiefly in the counties of York and Durham.

Two kinds.—There are two chief kinds, called, from the colour of the seed, the white and the black. The white grows to a height of about 2 feet, the stem and leaves are nearly smooth, and the seed is of a pale colour. The black is about 3 feet in height, the stem and lower leaves are rough, and the seed is of a dark-brown colour.

Cultivation.—The ground is prepared as for corn. The seed is sown in spring, broadcast or by drill. When the plants are a few inches in height they are thinned by hoeing. In summer they are covered with bright yellow flowers, which give place to the pods containing the seeds.

Preparation.—Like wheat, barley, oats, rice, &c., the mustard seed has an outside husk or skin. Formerly this was ground up with the flour, but now it is generally separated as the bran of wheat is. The mustard sold in the shops often consists of more than flour of mustard—turmeric (the root of a plant somewhat like ginger) being added to make it yellow; corn-flour to make it bulky, and capsicum (the fruit of the plant from which we get cayenne pepper) to make it hotter.

Oil and cake.—Instead of being ground mustard-seed is sometimes pressed, when a good deal of oil runs out of it. This oil is used to rub persons suffering from rheumatism. When as much oil as possible has been pressed out of the seeds they are made into oil-cake, which is used as food for cattle.[1] The same is done with the seeds of the flax after linseed oil has been pressed out of them.

[1] Oil-cake might seem too hot for food, but it should be remembered that the pungent properties of mustard are due to an acrid volatile oil which does not exist ready formed in the seeds, but which is produced from myronic acid by fermentation when the mustard flour is moistened with water

THE OAK

[Provide a picture of the oak; also specimens of the leaves, acorns, galls, and timber.]

General appearance.—The oak is a tree with a thick trunk and large spreading branches.

Roots.—Elicit that if such a tree were not held very firmly in the ground it would be blown down by storms, and that therefore it must have big, strong roots. When the tree is old some of these grow above ground. By referring to the way in which the roots of a plant in a pot suck up moisture, elicit that the oak feeds (partly) by its roots, and that for this reason also they must be big.

Timber.—The trunk grows outward, each year's growth making a ring round the older wood. Show the rings in a transverse section. The oak will live for hundreds of years. The timber is very hard. Hence it is used for making things which must be strong or stand wear. Name some things made of oak. Formerly nearly all ships were made of it, both because it is strong and will keep out water.

Bark.—Show. When the trees are felled the bark is stripped off and sold to tanners. It contains something called *tannin*, which changes skins into leather.

Acorns.—Show. They are the fruit of the oak, and if they are planted oaks will grow from them. Uncivilised people often eat acorns, but as they have a bitter taste, civilised people, having other articles of food for themselves, leave the acorns to pigs, deer, squirrels, rats, mice, and birds.

Galls.—Show. There is an insect which makes a little hole in the skin of the leaves and stalks and lays an egg there. Part of the juice of the leaf hardens into little balls around the egg. These are about as big as a marble, green at first, but brown when dry. They are called *oak-galls*, or *gall-nuts*, and are used in making ink.

SECOND YEAR

A: Lessons on Common Properties

HARD AND SOFT SUBSTANCES

Soft and hard.—Provide as many substances of different degrees of hardness as may be readily procured, such as soap, putty, clay, brick, bone, ivory, slate, chalk, indiarubber, wood of various kinds, glass, emery-paper, lead, zinc, copper, tin, iron, steel (and other metals if possible). Let the children try how many of these they can scratch with their finger-nails. Place these substances together as *soft*. The rest may be considered *hard*.

Comparative hardness.—By continued experiment make quite clear that the harder of two substances will scratch the other. Applying this test, arrange in order of hardness all the substances provided for illustration, and let the children note carefully the relative positions of the more important ones. Omitting the emery-paper, glass and steel will stand highest.[1]

Diamond.—Let a child try to make a mark on the glass with the point of a steel knife. '*What does that show about the hardness of the glass?*' If possible, borrow a glazier's diamond, and let a child scratch the glass with it. If one cannot be got ask what a glazier cuts glass with. '*What does that show about the hardness of the diamond?*' Diamond is the hardest substance. It can be polished only by rubbing with diamond dust, and it has lately been used for boring very hard rocks.

Emery.—Emery is a mineral.[2] It is made into a very fine

[1] *Order of hardness of metals.*—Steel, iron, silver, copper, platinum, gold, tin, bismuth, zinc, lead.

[2] It gets its name from being found at Cape Emeri in the island of Naxos.

powder and spread on glued paper. Elicit that as it is used to polish steel (which it does by rubbing off little bits) it must be harder than steel.

Steel.—Steel is the hardest of metals. Get the children to name various tools made of steel, and to see that these would be useless unless very hard. But steel may be made hard or soft. Provide a piece of steel such as a big needle. Prove its hardness by showing that a file will not mark it Warm it, and let it cool slowly, and with the file prove that it is now soft. Show that it will bend. Warm it again, and when it is red-hot cool it instantly by plunging it into cold water. Now prove that it is hard and brittle.

Alloys.—'*What are our coins made of?*' '*What would happen to them if they were soft?*' Gold, silver, and copper are softer than iron. To keep them from wearing out quickly they are mixed with harder metals, gold and silver with copper, and copper with tin and zinc.[1] Brass is a mixture of copper and zinc; pewter of tin and lead; type-metal (used also for shot and bullets) of lead and antimony.

FUSION

Solid and Liquid.— See that the children can distinguish between solids and liquids and ask about each of the substances produced whether it is a solid or a liquid.

Heat changes some solids into liquids.—Show a piece of ice or of butter. Warm it in an iron spoon watch-glass, or evaporating-dish. '*What change has taken place in it?*' '*What caused it to change from a solid into a liquid?*'

Perform the same experiment with other substances, such as tallow, wax, lead (which should be melted in an iron spoon). Emphasise the fact that each is at first a solid, and is changed by heat into a liquid.

All solids do not melt with the same heat.—If a piece of

[1] 'Gold' coins contain 11 parts gold, 1 copper.
'Silver' coins contain $92\frac{1}{2}$ parts silver, $7\frac{1}{2}$ copper.
'Bronze' coins contain 95 parts copper, 4 tin, 1 zinc.

ice has been provided, let a child hold it in his hand. The heat of the hand is enough to melt it. If no ice has been provided, let a child melt a small piece of butter by holding it between finger and thumb.

Let the same child try to melt the lead in the same way. Hence elicit the fact that heat which would melt the ice (or butter) will not melt the lead.

If there is a fire, put the poker or any other piece of iron in it. If there is no fire, hold a piece of iron wire in the flame of a spirit-lamp or Bunsen burner. The iron will not melt, but it becomes soft. By questioning about furnaces bring out the fact that at a very great heat iron will melt.

Show some mercury. '*Is this a solid or a liquid?*' It is the metal that melts most easily. Only in a very, very great cold will it keep solid.[1]

The heat of fire will not melt platinum. Show. Hence vessels for melting gold and silver are made out of platinum.

No one has yet succeeded in melting charcoal. Show.

Some substances burn instead of melting.—Bring this out by trying to melt paper, wood, coal, &c. That fusion and not combustion would take place if oxygen were kept from these substances may be ignored at this stage.

DUCTILITY, TENACITY, AND MALLEABILITY

Ductility.—Hold a glass rod by the ends, and warm the middle in the flame of a spirit-lamp or Bunsen burner. (Fig. 41). Show that when the glass has been softened it can be drawn out into a very thin 'wire.'

Perform the same experiment with sealing-wax.

Then show various metal wires and explain the method of making them. The metal is first made into rods about $\frac{1}{8}$ inch

[1] The melting-point is −38·8° Cent. The following are arranged in the order of the melting-point :—Mercury, ice, butter, phosphorus, white wax, sulphur, tin, lead, zinc, silver, gold, iron.

thick by being drawn while red-hot between grooved rollers. [There is no need to give the diameter of the rods, but show a piece of twine or a knitting-needle of the proper size.] 'The rods when cold are pulled through a draw-plate. The draw-plate is made of hard steel, and has a large number of holes growing gradually smaller and smaller. The rods are drawn through the largest hole first, then through the next, &c., till small enough.

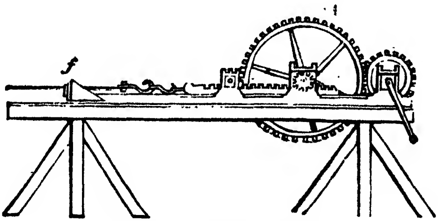


FIG. 12.—A Draw-plate (*f*).

Some metals cannot be made into very fine wire, as they break when being pulled through the smaller holes of the draw-plate. Lead breaks most, and platinum least, easily. Platinum has been drawn so fine that over 33,000 pieces would lie side by side in an inch. Show an inch.

Some of the finest wire in common use is the steel wire woven to form the gauze of safety lamps. Show wire gauze.[1]

Tenacity.—The best way to illustrate tenacity is to have thin wires of the same diameter but of different metals, and to suspend weights till the breaking-point is reached, making the children note the weight in each case. Where this cannot be done, let the same child break successive wires and note the comparative difficulty. Glass and sealing-wax will break very easily, lead less easily; the hardest of all to break is steel, and the next hardest ordinary iron. Hence the cables of great ships and the ropes for suspension bridges are made of steel wire.

[1] The order of ductility (as given by Ganot) is platinum, silver, iron, copper, gold, zinc, tin, lead.

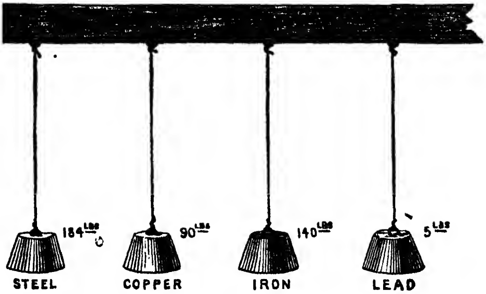


FIG. 13.

Malleability.—Using a flat piece of iron as an anvil, show that lead can be hammered out. Similarly hammer out a piece of copper wire. Then try to hammer out a piece of iron. By reference to a blacksmith elicit that iron can be easily hammered out when heated.

Some metals can be beaten very thin when cold. Gold can be beaten thinnest of all metals. Question about gilding, and show gold-leaf. To make this the gold is first pressed in a rolling-mill. Illustrate by two cotton-reels or compare to a mangle. By rolling, the gold is made into plates so thin that twenty-five of them would make an inch—in other words, the plates are about as thick as two playing-cards. These are then beaten thinner with a hammer, cut, and beaten again and again. Show with the lead or copper that when thin metal is hammered it gets torn. To prevent this the gold is placed between sheets of goldbeaters' skin. Show. Thus beaten, the gold can be made so thin that 300,000 leaves would make only an inch. Show an inch, and show how many leaves of a paper book make an inch.

Dutch metal, a kind of brass, can also be hammered out very thin. Show various metal foils and ask about their uses.

The terms.—Anything which can be drawn out into wire is said to be *ductile*; anything that is difficult to break is said to be *tenacious*; and anything that can be hammered out is said to be *malleable*.

In recapitulation produce wood, glass, sealing-wax, metals, &c., and ask to what degree they possess each of the properties dealt with in the lesson.

IRON[1]

Iron is hard and strong.—Get from the children and write on the blackboard the names of a few things made of iron, such as ships, bridges, pillars, engines, &c. *'Why would not lead do for these things?'* Iron is used because it is hard and strong (or tenacious).

Question briefly about the test of comparative hardness given in a former lesson, and apply it to show that iron is the hardest of the metals.

Similarly revise the lesson on Tenacity.

Iron can be welded.—Heat two pieces of iron wire and weld them. Question about the work of a blacksmith. Iron is one of the very few metals which can be joined (or welded). Show how much less useful iron would be if it could not be welded.

Iron can be hammered out.—Show piece of sheet iron, and get from the children names of things made out of it.

Iron can be drawn out.—Briefly revise lesson on Ductility. Show iron wire, and get names of things, great and small, made of it.

Iron ore.—In many parts of the country large quantities of a kind of stone called iron ore are found. Show. This is generally a mixture of iron, clay, and lime.

Furnace.—Show a picture of a furnace. By reference to the lesson on Fusion remind the class that at a very great heat iron will melt. *'If you want the fire at home to light up quickly what do you use?' 'What comes out of the bellows?'* To get in the furnace the great heat needed to melt iron a blast of air is kept passing through.

[1] This and the lessons immediately following it are intended partly to apply to special cases the preceding lessons on properties, and partly to give some information about the origin and preparation of the common metals.

Into the furnace a mixture of iron ore, limestone, and coke is thrown. The lime, the coke, and the coal take away from the iron ore nearly everything except the iron. Into a tumbler of water drop a piece of wood and a piece of iron. '*Why does the iron sink while the wood floats?*' '*What will the iron in the furnace do when it is melted?*' [Sink to the bottom.] '*Why?*' A hole is then opened near the bottom of the furnace, and the iron runs out into grooves made in sand. Illustrate by a sketch on the blackboard. This iron is called *cast iron.* Show some cast iron. Ask the children to name things made of it. By exhibiting a broken piece, or by breaking, show that it is brittle.

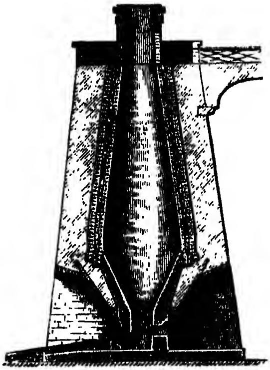


FIG. 14. – Section of a Blast Furnace.

Wrought iron.—Cast iron is brittle because it contains a good deal of charcoal. Show. To get rid of the charcoal a draught of very hot air is passed over the melted cast iron, which is also stirred or puddled. In this way the charcoal is burnt off and *wrought iron* is left. This is very tough, and can, when cold, be drawn into wire, and hammered into any shape when heated.

Steel.—Steel contains less charcoal than cast iron and more than wrought iron. It can be made hard or soft by *tempering.* Repeat experiment from the lesson on Hard and Soft Substances.

LEAD

Properties and uses.—Let the children compare the weight of lead with the weight of other substances. They will discover that it is *heavy.*

Let them scratch it with their nails. It is *soft.* It makes a mark—that is, it is so soft that little bits of it come off

when rubbed—on paper. The 'blacklead' of which pencils are made is not a kind of lead.

Lead *melts* easily. Show this by melting some in an iron spoon. Because lead is heavy and melts easily it is used for shot. Show some. The melted lead is poured into a vessel with holes in the bottom ['*Why?*'], and allowed to fall a great height ['*Why?*'] into cold water. '*Why?*' '*Who has seen a shot-tower?*' '*Why would it not do to have soft shot?*' Hammer shot and small pieces of lead to show comparative hardness. The shot is made hard by mixing a little arsenic with the lead.

Show solder. Question about its use, and elicit that it must melt easily. Lead melts easily, but is too soft for solder, which is an alloy of lead and tin.

Show the lead lining of tea-chests. The Chinese make this by pouring melted lead on one smooth flat stone and placing another upon it.

Lead is *malleable*. Show this. Show a piece of 'milled' sheet lead. This could be made by hammering. It is made by being passed between rollers. Illustrate.

Lead is *flexible*. Show that sheet lead and lead piping can be easily bent, and that they are not elastic. Bring out by questions that lead is adapted by its flexibility for use on roofs, as lining of cisterns, for gas and water pipes, &c.

Pure lead is *bright*. Cut a piece, and contrast the colour thus exposed with the dull grey surrounding it. This grey is a kind of rust, but as it does not dissolve in ordinary water there is little danger in using lead for the lining of cisterns.

Lead ore.—The most common lead ore consists chiefly of a mixture of lead and sulphur. This is found in many parts of the British Islands.

Roasting.—The ore is first picked, broken, and washed to separate the earthy parts. The remainder is then roasted in a kind of long, low oven to burn away the sulphur.

Smelting.—The roasted ore is placed in a furnace and melted. When melted, the lead sinks to the bottom ['*Why?*'], and the impurities rising to the top can be skimmed off. The lead is run into moulds, and is called *pig lead*.

COPPER

Properties and uses.—Produce some copper wire. Copper can be drawn out into finer wire than any ordinary metal, except gold, silver, and iron. Prove by experiment that copper wire is very tenacious (iron alone is more tenacious) and flexible.

Hammer out a piece of copper wire to show that the substance is malleable. When hammered or rolled out into sheets it is very elastic. Sheet copper is used for scuttles, kettles, &c.

Also used to cover those parts of a ship under water, to protect the wood from creatures living in the sea.

Copper is a loud-sounding metal—hence used for gongs, bells, &c.

Telegraph wires are generally made of copper. [The reason —viz. that copper is of all metals the best conductor of electricity—need not be given at this stage.]

Copper rust is green. Show. It is very poisonous. As sour fruit, vinegar, and other things cause copper to rust, the metal must not be made into any vessel used in cooking.

Copper ore.—The most common ore of copper is a mixture of sulphur, copper, and iron. It is found in Cornwall, Devon, Anglesey, Westmoreland, Cumberland, &c. Show.

Roasting and smelting.—The process of getting pure copper from the ore is too long and complicated to be described to young children. It consists of a series of roastings and smeltings.

Alloys.—*Brass* [Show] is an alloy of about two parts of copper to one of zinc. The two metals are melted and mixed, and then cast into plates. Brass is malleable and ductile when cold. It melts more easily than copper, can be polished brightly, and does not rust quickly. Made into pins.

Bronze.—Copper and tin. Very hard; formerly used for weapons. Now used for statues. Also for coins.

Dutch metal.—Show. Eleven parts of copper and two of zinc. Almost as malleable and bright as gold. Used for 'gilding' cheap frames, &c.

TIN

Properties and uses.—Tin is of all common metals the *easiest to melt.* It will melt in the flame of a candle. [Melt some. If pure tin cannot be obtained, melt some tinfoil.] Tin, therefore, cannot be employed in any articles to be exposed to great heat.

Tin is *very malleable.* Show tinfoil. A thousand sheets of the thinnest foil would be only an inch thick. Ask for the names of things packed in tinfoil. '*Why is the foil superior to paper?*' [Not being porous or absorbent it keeps out damp, and keeps in the aroma of the articles packed in it.]

Tin *does not rust easily.* Show a piece of rusty iron. '*What caused it to rust?*' [The damp air.] Revise that part of the lesson on Copper which dealt with copper rust. Cooking vessels made of iron or copper are therefore lined with tin.

What is often familiarly called tin is really *tinplate.* This is tinned iron. Thin sheets of iron, first thoroughly cleaned, are dipped in melted tin. '*Why?*' It would be useful to have frying-pans and gridirons tinned. '*Why are they not?*' [The heat to which they are exposed would melt the tin.]

Tin is *soft.* Show that it can be cut with a knife.

It *can be bent,* but is *inelastic.* Show.

It has *little tenacity,* therefore not used for wire.

Alloys.—*Pewter* is an alloy of tin and lead. [The better kinds have antimony and copper instead of lead.] '*Uses and properties?*'

Britannia metal, a superior kind of pewter. '*Uses?*'

Bell-metal and *bronze,* chiefly copper with some tin.

Solder, tin and lead. '*Uses and properties?*'

Manufacture.—Tin ore is found in Cornwall. [If possible show some.] It is first crushed and then washed. Much of the dirt passes away with the water. The ore is then roasted, like copper ore, to drive away any sulphur which there may be in it. Mixed with small coal and slaked lime, and strongly heated, it gets rid of most of the remaining impurities. It is then melted, and the impurities rise to the surface and are skimmed off.

ZINC

Properties and uses.—Show a piece that has been exposed to the air for some time. It is dull. A little scratching will expose a bright surface. Only a very thin coat of rust forms on it, and this is not poisonous.

When cold, zinc is not malleable; but when heated, it can be hammered or rolled out into sheets. These are flexible, and, as zinc is lighter than lead, it is used for roofs, gutters, pipes, &c.

Zinc is hard. Show that of the common metals it comes next to iron and copper in hardness. For the properties named it is used to make vessels for holding water—baths, pans, cans, &c. The fact that its rust is not poisonous also leads to its use in cisterns, but it is said to give a taste to the water.

Its hardness and indisposition to rust cause it to be made into saws for cutting blocks of salt. Elicit that iron saws would rust.

Zinc and lead make a very ductile alloy. This wire is cheaper, softer, and more flexible than iron or copper wire. Used by gardeners for tying trees and shrubs and fastening labels. *'Why?' 'Why would not twine do?' 'Why would not iron wire do?'*

Just as iron for saucepans, &c., is coated with tin to prevent rust, iron for roofs, fences, and the walls of temporary buildings is coated with zinc. The iron is dipped into melted zinc. The wrinkling (corrugating) gives strength. Refer to some place in the neighbourhood where galvanised iron (as it is called) is in use.

Preparation.—The British Islands are not rich in zinc. Much of the ore we use is imported from Spain and Italy.

The ore is first roasted to drive off the sulphur. It is then mixed with coal or charcoal and placed in large earthenware jars in a furnace. From each jar an iron tube passes into a vessel containing cold water. The zinc after melting passes through the tube as vapour, and is condensed in the water.

PINS

Properties.—Provide :—

(1) A piece of thick wire. [Part of a knitting-needle will do.]

(2) A crooked pin.

(3) A pointless pin. [Cut the point off with a pair of pincers.]

(4) A headless pin. [Cut off head with pincers.]

(5) A piece of rough wire. Ask children to fasten pieces of stuff with these things, and thus elicit that a pin must be

(1) Thin.

(2) Straight.

(3) Sharp.

(4) Headed.

(5) Smooth.

Manufacture.—(1) Show that a needle is hard, and will break if bent. Show that a pin is soft, and will not break if bent. '*What are needles made of?*' [Steel wire.] '*What are pins made of?*' [Brass wire.] Show.

(2) Revise what was said about wire-making in the lesson on Ductility, and add that brass wire of the proper thickness is supplied to the pin-maker.

(3) *Cleaning.*—Pour a few drops of sulphuric acid into a little water. Place a penny in the mixture, and then rub it. It will become as bright as when new. The brass wire is cleaned in much the same way. '*Why must it be cleaned?*'

(4) *Straightening.*—'*Why must pins be straight?*' The wire is straightened by being drawn between six or seven smooth iron pegs set upright in a table nearly in a line and some distance apart. The wire is made to pass on the left of one peg, the right of the next, &c. Illustrate by drawing a piece of wire between some nails fixed in a piece of wood.

(5) *Cutting and sharpening.*—The wire is cut into lengths for six pins. Illustrate with a piece of brass wire. Both ends are sharpened by being ground first on a steel wheel cut like a file [Show a file, and how it acts], and then on a grindstone.

Lengths for two pins are cut off, and the ends are again sharpened. Two more lengths are cut off, and when the remaining ends are sharpened the wire is cut in the middle.

(6) *Heading.*—Smaller and softer wire is taken and wound spirally round a long piece of stiff wire of the same diameter as the pins. The coil is then cut up into bits containing two or three turns, each bit to form one head. Pins are then dipped into a heap of heads till each pin has taken up one. The pins are then placed point down in holes in a piece of steel, and the head is hammered on.

(7) *Tinning.*—Refer to the tinning of iron for tinplate, and the zincing of iron for galvanised iron. Pins are tinned by being dipped into melted tin. '*Why are they tinned?*'

(8) *Drying and polishing.*—The pins are dried and polished by being turned round in a barrel containing bran.

(9) *Papering.*—Show a paper of pins, and explain the papering.

PENS

[Specimens showing every stage in the process of pen-making may sometimes be obtained through the generosity of manufacturers, and can always be bought from some of the school publishers. These specimens form the best possible illustration of a lesson on Pens—indeed, they almost form a lesson in themselves.]

Material.—Pens are made of 'ribbons' of the best steel.

Cleaning.—'*How was the brass wire used in making pins cleaned?*' The steel for pens is cleaned in the same way.

Rolling.—The ribbons are passed between steel rollers till they are of the right thickness. Compare to a mangle, and illustrate with two cotton-reels.

Blanks.—By means of a punch pieces (called 'blanks') are cut out. These are of the same shape as a pen would be if flattened out.

Piercing.—Show the hole at the top of the slit. This is punched out, and the side slits, if any [Show pens with some], are cut at the same time.

Softening.—The next processes are marking and 'dishing'

or curving; but the steel is at this stage too hard for either, and it must therefore be softened. Refer to the lesson on Hard and Soft Substances, and ask how steel is softened. The 'blanks' are placed in an iron box, heated, and allowed to cool slowly.

Marking.—Show the maker's name and other marks. These are stamped on the soft steel.

'**Dishing.**'—The 'blanks' are then curved by being pressed into grooves. Illustrate by pressing a piece of thick paper into a groove.

Hardening.—The pens are then hardened. Again refer to lesson on Hard and Soft Substances. The pens are hardened by being heated and plunged into oil.

Tempering.—Show that a pen is elastic, and that an inelastic pen would be useless. The desired elasticity is given by tempering. The steel is heated (but not made red-hot), and is allowed to cool.

Grinding.—The pen is now properly pointed by grinding on a wheel made of emery powder and clay baked together. Refer to 'Emery' in the lesson on Hard and Soft Substances.

Slitting.—By means of a quill show that a pen which has no slit will not write. Each pen is laid on a chisel the edge of which reaches from the point to the hole. A similar chisel is forced down. The two meet, and the pen is slit.

Heating.—The pens are coloured by heating. The shade of colour depends on the amount of heat employed.

B: Lessons on Animals

THE LION AND THE TIGER

Revise rapidly lesson on the Cat. Treat the lion and the tiger as in structure and habits very like large cats.

The lion.—*Found* in Asia and Africa.

Size.—Show picture. The lion is about 4 feet in height at the shoulder. Show 4 feet.

Colour.—Tawny, the same colour as a mastiff. This is the colour of the sandy deserts in which the lion lives. Elicit that

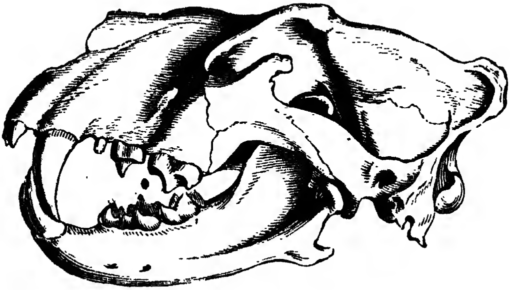


Fig. 15. Skull of Lion.

the animal can therefore hardly be distinguished from surrounding objects by day, and not at all by night.

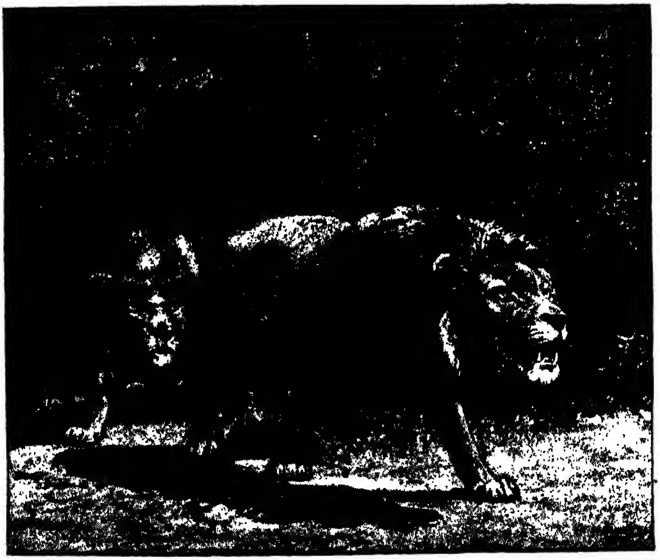


Fig. 16.

Mane.—The lion when full grown has a thick, shaggy mane. The lioness has no mane.

Tail.—The lion differs from the cat in having a tuft at the end of the tail.

Climbing.—The lion also differs from the cat in being unable to climb.

Teeth as in the cat. Draw teeth, and show that they are formed for tearing alone. Even the back teeth are unfit for grinding, and as the lion's jaws move only up and down, grinding would be impossible with any teeth. (Fig. 15).

Whiskers, *feet* (with pads), *claws* (with sheaths), and *tongue* as in the cat.

Prey.—The lion, like the cat, does not chase its prey. It creeps silently up until about 20 feet off, and then springs. The lion is so strong that it can pull down and kill an ox or a horse and drag it away.

The tiger.—*Found* only in jungles in certain parts of Asia.

Size.—Show pictures of lion and tiger, and ask children to compare the two animals. The lion is a little taller, but certainly not stronger, fiercer, or more cunning.

Colour.—Bright gold with black stripes. Elicit, as in the case of the lion, that this makes the animal hard to distinguish, the yellow being of the same colour as the tall grass amidst which the tiger lives, and the black stripes like the shadows.

Structure.—There is no tuft to the tiger's tail. In other respects it resembles the lion.

Hunting.—Tigers often lie in wait for men and kill many. They are therefore hunted more steadily than lions. Describe methods : (1) Traps ; (2) By men on elephants.

THE WOLF AND THE JACKAL

Revise rapidly the lesson on the Dog, and dwell on the fact that in structure and habits the wolf and the jackal are really only fierce, wild dogs.

The wolf.—*Found* in nearly every part of the world, hot or cold. Wolves were once common in the British Isles.

Size.—Show picture. The wolf is about 2½ feet high at the shoulder, and about 3½ feet long from the muzzle to the root

of the tail. Show these measurements, and compare the wolf in size to a St. Bernard or big Newfoundland dog. The tail (which is bushy like a collie's) is about 1½ foot long.

Structure.—The muzzle also resembles a collie's.

The ears are pointed and upright.

The eyes are set slantingly.

The teeth are like a dog's. The bite of the wolf differs from that of the cat tribe. The lion and the tiger seize their prey and then drag it to the ground. The wolf is not strong enough for this, so it gives a large number of sharp, quick, snapping bites, the teeth meeting each time in the flesh. In this way the animal attacked soon falls from loss of blood.

Habits.—By reference to a fox-hunt elicit that dogs chase their prey in packs. Wolves do the same. Hardly any creature is too large for them to attack. Going at a long, swinging gallop they will follow for hours the creature they have chosen. When they overtake it they fall upon it from all sides, and soon bring it to the ground. They will devour even a horse in two or three minutes, and then they often fight among themselves, eating up those of their number which are hurt or killed.

Wolves are as cunning as foxes. Tell some story to illustrate this.

Wolves are very fierce and savage, but when caught very young they can be tamed, and they then become as friendly as dogs.

When alone a wolf is cowardly, never, except when half mad with hunger, daring to attack a man.

The jackal.—*Where found.*—The two most common kinds of jackals are found, one in India, and the other in South Africa.

Structure.—The jackal differs from dogs and wolves in having a very long, pointed muzzle. It is also smaller than the wolf, being only about 18 inches high at the shoulder. Show this, and compare the jackal to the collie in size.

Habits.—Jackals are rather cowardly. Like wolves, they hunt in packs, and united they can pull down a deer. They search for food at night, making a hideous yell.

The jackal has been called the lion's provider, from the

belief that it finds the prey which the lion kills. This is an error. Jackals often follow lions and tigers in the hope of securing what they fail to eat up.

Like the wolf, the jackal if caught young can be tamed.

THE ELEPHANT

Where found.—Elephants live in the forests of Asia and Africa. Ask who has seen an elephant. '*Where did it come*

Fig. 17.

from?' The elephants seen in circuses are always Asiatic; the African is hunted for its ivory, not tamed. The African

elephant generally has larger tusks, and always very much larger ears, than the Asiatic.

Size.—The elephant is the largest land animal. It is generally 8 or 9 feet high, but sometimes reaches 10 or 11 feet. Show these heights.

Legs.—'*What kind of legs must the elephant have to hold up its great body?*' Show the thick, short, straight legs.[1]

Compare with the legs of a race-horse in each respect.

Feet.—The foot is very large. '*Why?*' The hoof surrounds it, and is formed of a vast number of horny springs not unlike carriage springs. Elicit the effect of these, and tell that herds of elephants can pass through a forest almost without noise.

Skin.—Elicit that as the elephant lives in very warm countries it needs no fur and has little or no hair. Elicit also that as it passes through the forest, where it is liable to be scratched, it needs a thick, hard skin.

Head.—Show that the head is large.

Tusks.—From the upper jaw (in all African elephants, and in a considerable number of the males of Asiatic elephants) grow two very long teeth, called tusks. These yield the best ivory, and are very heavy, weighing from 60 or 70 lbs. to about 140 lbs.

Trunk.—Contrast the neck and head of the giraffe with those of the elephant. Place a weight at the end of a stick, and let the children discover experimentally that the weight is easiest to lift when the stick is shortest. Thence show that the heavy head and tusks of the elephant need a short, stout neck.

Elicit that with its short neck the tall elephant could not reach food from the ground. Hence the need for the trunk. The trunk is really a very long and strong nose with a finger at the end. It can seize anything and turn in any way. It carries food and water to the mouth. Without its trunk an elephant could not live.

Teeth and food.—The elephant has no tearing or cutting

[1] A child is said to have described an elephant as a square animal with a tail at each end and a leg at each corner.

teeth. Its teeth are formed for grinding only, and it therefore lives on plants, leaves, fruits, and grains.

Habits &c.—Give brief sketches of the hunting and taming of elephants. The school reading-books will probably furnish stories to illustrate the sagacity, strength, and other characteristics of the animal.

THE CAMEL

Kinds.—There are two kinds of camels, the Arabian, which is single humped, and the Bactrian, which is double humped. This lesson deals with the Arabian only.[1]

Where found.—In Arabia and North Africa. Describe as vividly as possible the deserts over which the camel has to pass, with their loose sand often blown into blinding, suffocating clouds, and with their absence of food and water. The remainder of the lesson will show how the camel is adapted by its structure for crossing such deserts.

Size.— About 7 feet high—higher than a tall man.

Covering.—Long hair, some coarse and some fine. The coarse hair is woven into cloth. '*Who wore a garment of camel's hair?*' The fine hair is made into brushes for painting. The colour is an ashy brown.

Teeth.—The camel chews the cud. Refer to the teeth of the cow. The teeth of the camel differ somewhat from those of the cow; one great difference is that the camel has cutting teeth in the front of the upper jaw.

Food.—Elicit from teeth that the food must be vegetable. It consists of grass, leaves of trees, dates, beans, grain, &c.

Stomachs.—Refer to stomachs of the cow and the sheep. Elicit that the camel would perish with thirst if it could not go for a long time without water. It can do this by means of the cells in its second stomach. When the camel drinks it fills these cells and then closes them. When it becomes thirsty it

[1] The dromedary is often spoken of as if it were a distinct species. It is only a lighter variety of the Arabian camel, used when great speed is required. The dromedary is related to the ordinary Arabian camel as the hunter is to the dray-horse.

opens them and allows a little water to escape. In this way the animal can go for about a week without drinking.

Hump.—The hump is not a deformity, as the camel's 'backbone' or spine is as straight as a horse's. The hump is made up chiefly of fat, and seems intended to keep the animal alive when it can obtain no food. At the end of a long journey the

FIG. 18.—The Camel.

hump is almost gone, and the camel is not allowed to travel again till the hump has grown to its old size.

Legs and Feet.—Ask what would happen if a horse tried to walk over loose sand. Describe the large, broad 'shoes' by means of which men in cold countries walk over the snow. Show picture of the camel's foot, which consists of large elastic pads. These spread as the foot is placed on the ground.

The camel has to kneel when being loaded. '*Why?*' '*What would happen to the knees of a horse if it had to kneel often on the rough sand?*' The knees of the camel and the part of its chest which touches the ground are protected by hard leathery pads.

Eyelids.—'*What happens to our eyes when the dust is blowing?*' '*What would happen to them if we were caught in a sandstorm?*' The camel has shaggy, overhanging eyelids, which protect the eye from sand and from the bright sun.

Nostrils.—Elicit that sand would suffocate if it got into the nostrils. The nostrils are long, and can be completely closed so that they look like a narrow slit.

Temper.—It is a mistake to suppose that the camel is mild and gentle. It is sulky and bad tempered. Its legs often have to be tied before it will allow itself to be loaded or even unloaded, and it fights other camels.

THE BEAR

Size &c.—Show pictures of various kinds of bears. Ask who has seen performing bears, and then question about size, shape, colour, length of legs, &c.

Teeth.—The teeth are formed both for tearing and for grinding, and bears, therefore, live on flesh and vegetables (roots, corn, fruits, &c.).

Elicit that animals built like the bear could neither catch nor creep up to other animals.

Feet.—Get from the children who have seen a performing bear that it stood easily on its hind legs. Sometimes a dog can be trained to stand with some difficulty on its hind legs, but animals of the cat and the dog tribes usually cannot stand on their hind legs, because they walk on their toes. Bears can, because they walk on the sole of the foot (see Fig. 19).

When fighting, bears stand on their hind legs and strike or hug with the front legs.

Paws.—All the paws have strong, sharp claws; no sheaths.

By means of its claws the bear can climb and dig easily. *'Why should it want to climb?' 'And to dig?'*

Hibernation.—Bears generally sleep through the winter. Elicit that fruits are plentiful in autumn, and not to be found in winter. Bears, therefore, get very fat in the autumn. About October they dig themselves dens under rocks or beneath the roots of trees, and there they pass the cold months without eating and seemingly half dead. Speak of the thick, warm fur of the bear.

Kinds.—The bear generally seen in England is the *Brown Bear*, which is found in the woods and forests of several parts

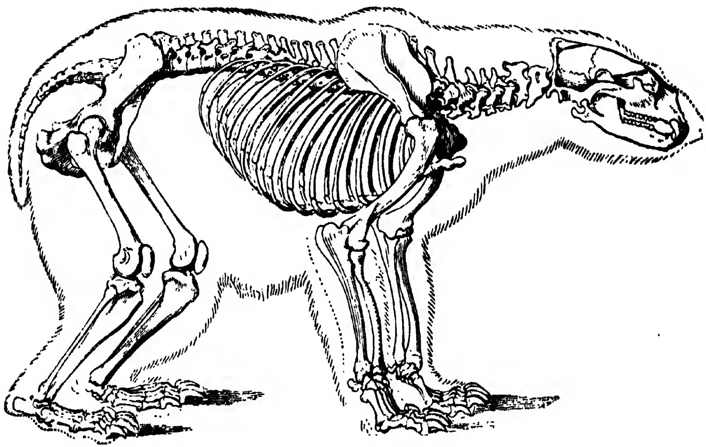


FIG. 19. - Skeleton of Bear.

of Europe and Asia. This bear is fond of ants and their eggs, and of honey.

The *Black Bear* is found in many parts of North America, but as it is much prized for its fine fur it is not so common now as formerly. Lives chiefly on vegetable food.

The *Grizzly Bear* is also found in North America. It is very fierce and strong, and will readily attack man. The colour varies greatly, but there is always a tendency to whiteness in

the surface of the fur : hence the name *grizzly*. This bear lives upon animals of all kinds as well as upon vegetables.

The *White Bear* is found in the Polar regions. The feet are very long. Elicit that they are good for swimming. The

FIG. 20.

soles covered with a very thick coating of warm fur. Elicit that this will keep the feet warm and prevent their slipping on the ice. Lives chiefly on fish. '*Are there any fruits in the cold North?*' Also fond of seals. The female sleeps through the winter, but the male does not.

THE RABBIT

[For illustration have a living tame rabbit and a picture of a wild rabbit. For the teeth have a skull.]

Home.—Rabbits live in holes, called 'burrows,' which they make in the ground. These run for a good way and mostly have more than one entrance, so that if a ferret, weasel, or dog should follow the rabbits they can escape.

Fig. 21.

Large numbers of rabbits often live near each other. Their burrows are then called a 'warren.'

Teeth.—Revise what was said about the teeth of a mouse. The rabbit is, like the mouse, a gnawing animal. Show the two long teeth with chisel edges in front of each jaw. At the back of each jaw are grinding teeth. To show the action of the

teeth and jaws try to get the living rabbit to eat some green stuff.

Food.—Elicit that as the rabbit has no tearing teeth it cannot live on flesh ; but that as it has grinding teeth it lives on vegetable food—wheat, barley, turnips, and other growing crops.

Rabbits do great damage in the farmers' fields. As they have a large number of young ones every year, they would destroy everything around them if many were not killed. Speak about the enemies of the rabbit—foxes, weasels, sometimes cats, and man with guns, dogs, ferrets, traps, and nets.

Rabbits do great damage to young trees, delighting to strip them of their bark as far up as they can reach standing on their hind legs. Sometimes they eat it, but more often they leave it in heaps on the ground, having gnawed it off merely to keep their teeth in order, just as a cat keeps her claws in order by scratching the legs of tables and chairs.

Lips.—Upper lip split. Show. The hard substances which the rabbit gnaws would cut the lips, mouth, and tongue if they were formed like ours. The front teeth project, and the cleft in the upper lip enables that to be drawn back. There is also a patch of hair inside each cheek ; the skin of the tongue is thick and hard [Show the white patch], and the roof of the mouth has thick, horny ridges. Show.

Ears.—Elicit that as the rabbit has so many enemies it must be very watchful, and requires good ears and eyes. The ears are long and movable. '*Advantage of this?*' When going into a hole the ears are laid flat on the neck.

Eyes.—Large and bright, placed one on each side of the head. Elicit the advantage of this. We can see only what is in front of us ; the rabbit can see nearly all round.

Legs.—Long and thick, showing that the rabbit can run very fast. '*Why does it need to?*' Hind legs longer than front, enabling it to jump well. '*Other animals with hind legs longer than front?*' [The kangaroo is a notable example.]

The rabbit can sit up on its hind legs.

Feet.—The feet have spreading toes, and the front toes have strong, blunt claws. '*What do animals like the cat use their claws for?*' '*And the mouse?*' '*And the rabbit?*'

Whiskers.—'*Other animals with whiskers?*' '*Use of the whiskers?*' '*Why does the rabbit need whiskers?*'

Covering.—Soft, warm fur—so soft and warm that the skins are used to make muffs, caps, &c., and to line cloaks. '*Why does the rabbit need warm fur?*'

Very young rabbits have no covering, and the mother makes for them a very warm nest of dried grass and its own fur.

Elicit that as the rabbit makes its burrows chiefly in sandy soil, its sandy brown fur keeps its enemies from seeing it easily.

Tame rabbits.—Ask for the differences between these and wild rabbits. These differences are caused by greater care in feeding &c.

THE BEAVER

Found.—Some beavers are found in the northern parts of Europe and Asia, but their great home is now the northern part of North America. Impress upon the children that the climate of those parts is very cold, and elicit that as the beaver spends most of its time in the water it needs a specially warm covering.

Fur.—The beaver has two coats of fur—an under layer of short soft grey hair lying close to the body, and an upper layer of thicker and longer chestnut hair forming a kind of thatch. Because of its warmth beaver skin is much valued for muffs, jackets, cloaks, &c.

Feet.—'*What sort of feet has the duck?*' '*Why are they webbed?*' The hind feet of the beaver are webbed for the same reason.

Tail.—Compare the tail to the rudder of a boat and to the screw of a steamship. It is covered not with fur but with scales. '*Like?*'

Teeth.—The beaver is a gnawing animal. '*Like?*'

Food.—It lives on the bark of trees.

Size.—The beaver is the largest of the gnawing animals. It is over 2 feet long from the nose to the root of the tail, and the tail is over a foot long.

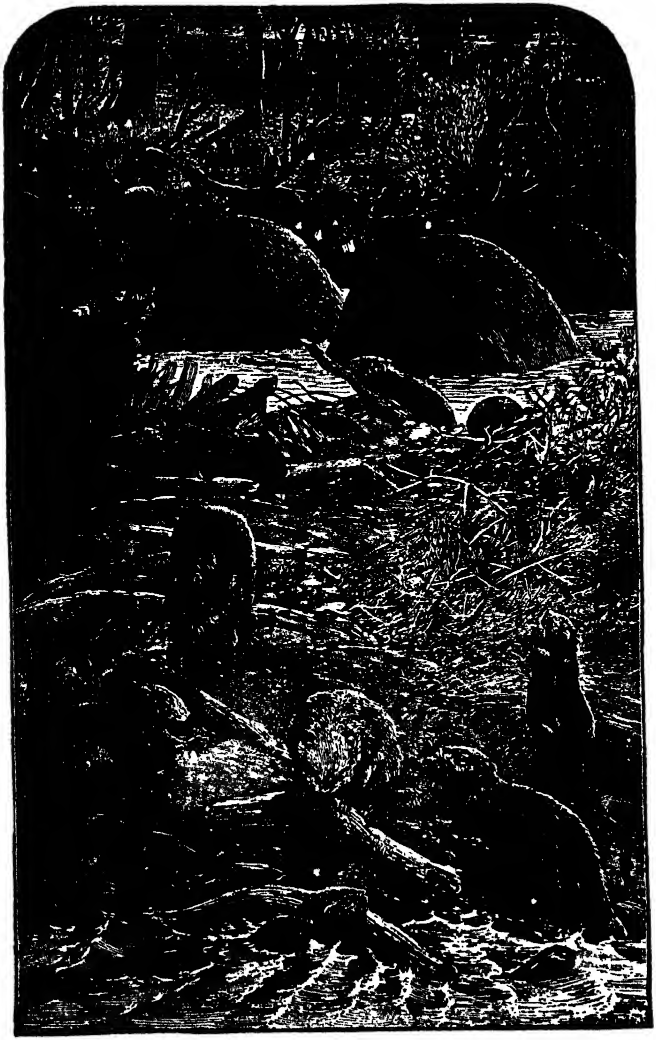


FIG. 22.

Dams.—In very cold countries the streams are often frozen down to the ground, and in the short, hot summer they are sometimes dried up. To keep both these things from happening in the streams where they live, beavers make the water much deeper by building great dams right across them. Illustrate by a good blackboard sketch, or by having a box or little trough for the bed of the stream, and compare to a mill dam or to the big pool the children themselves may have made by damming back the water in the gutter on a rainy day.

FIG. 23.

Having chosen a suitable spot where there is a tree growing on the bank, the beavers gnaw at it till it falls across the stream. Should one tree not be long enough, they similarly gnaw another on the opposite bank. These trees form the foundation of the dam. A large number of logs and sticks are then gnawed, floated down the stream, pressed among the branches, and secured with mud and stones. Layer upon layer is formed in this way till the dam is high enough. An opening is left at the top. '*Why?*'

The labour spent in building dams must be very, very great, as they are 12 feet thick at the bottom and sometimes 300 yards long. '*How many times as long as the school?*'

[It is a popular error to suppose that beavers use their tails as trowels.]

Lodges.—Near the dam the beavers build their 'lodges.' These are huts formed of branches, moss, and mud, in which several beavers live together. The walls are very thick, and, as the winter's cold freezes the mud, they defend the beavers against their enemies.

Around the 'lodges' deep ditches are dug, and as each 'lodge' opens into a ditch the animals can pass into the stream without going over land.

Winter food.—Beavers strip the bark from the logs used in

building their dams and store it for food in the winter. They also cut a vast number of small logs and fasten them under water near their 'lodges.' When they feel hungry they dive for one of these logs, peel off the bark, and eat it, leaving the log to float down.

THE SWALLOW

[Except in towns that the swallow does not visit, this lesson should be given during the summer. If a bird cannot be procured, illustrate by means of a good picture.]

The swallow is a 'bird of passage.'—By means of questions bring out clearly

(1) That the swallow is oftenest seen flying about swiftly, not in a straight line, but in all directions.

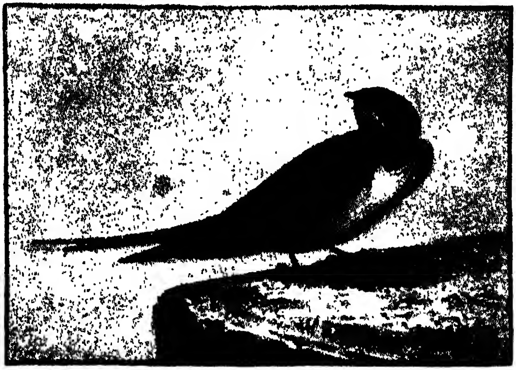


FIG. 24.

(2) That while flying it feeds on insects.

(3) That insects abound in warm weather.

(4) That the swallow is in this country only during the warmest half of the year, arriving about the beginning of April and leaving about the end of September.

Birds which, like the swallow, spend only a part of the year in a country, are called *birds of passage.*

Shape.—Draw outlines of two boats, one narrow with sharp bow, the other broad with flat bow. Ask which boat would pass most quickly through the water. '*Why?*' Then make children see that the swallow's body is shaped like the first boat. Contrast with the body of a hen.

Wings.—Very long, narrow, and pointed. '*Why does the swallow fly about so much?*' '*What sort of wings must it have to enable it to fly about so much?*' Compare wings with a hen's. Also with an eagle's or owl's. '*And to carry it to far countries?*' The swallow is believed to fly from Great Britain to the north of Africa in three days. The eagle and owl do not want to fly fast or far, but to keep up a long time and to carry their heavy prey. Their wings, therefore, are strong, but broad, not long. *Why broad?*' As the swallow has to catch insects as they fly, it must be able to dart through the air, and it has no weight to carry; hence shape of wings.

Legs.—Short and weak. Feet with four sharp claws, three pointing forward (four in the swift). '*What birds have you seen hopping about?*' '*Have you ever seen a swallow hopping about?*' '*Why cannot a swallow hop?*' '*Why does it not need long or strong legs?*' '*Have you ever seen a swallow hanging by a wall?*' '*How did it hang?*'

Beak.—'The beak is short and so weak as to be almost soft, but of vast width proportioned to the size of the body. This may be easily seen in the common house-swallow, but more particularly in the swift or large black swallow and goat-sucker, whose heads may be almost said to be all composed of mouth, so wide and gaping are their large, short beaks. Consequently, when the supply of food is abundant they have little more to do than fly with open mouth and close their beaks upon the objects which cross their flight. This the swallow does with a sharp clicking jerk, which may be heard by an attentive listener on a calm day at a considerable distance.'—*Stanley's* '*Birds.*'

Kinds (with nests).—(1) *The swallow* (proper).—Can be distinguished from the swift or martins by its steel-blue upper plumage and the two very long feathers that edge its forked tail. 'The swallow has perhaps never been known to build a

nest in the open air. In barns and outhouses, upon the beams of wood which support the roof, or on some stone jutting out of the wall or chimney . . . we find its nest.'—*Dixon's 'Rural Bird Life.'*

Question about building of nest.

(2) *The house-martin.*—Resembles the common swallow in habits and appearance. Can be distinguished from it by the large white patch on its back and the absence of the acutely forked tail. 'Unlike . . . the swallow and sand-martin, the house-martin builds its nest in the open air, . . . on the rocks, under the eaves of buildings, or on the sides of windows or chimneys.'—*Dixon.*

(3) *The sand-martin.*—Smallest of swallows. Back and head soft brown; quill feathers of wings and tail black; breast white, with a band of brown across the upper part. Builds its nest in sandy cliffs, banks of rivers, &c. Makes a narrow tunnel from 18 inches to 4 feet long, and at the end builds a nest of grass and feathers.

(4) *Swift.*—Is unlike the true swallows in several respects—one already mentioned (all four toes pointing forwards). Swiftest; cuts through the air as though shot from a bow. Makes a shrill noise, whence it is called in some parts of the country, 'Jack Screamer.' Nest made of feathers and grass placed in a hole in a wall or rock or under a roof.[1]

[1] The following table, giving the names of the most common birds of passage, with the earliest dates of arrival and latest dates of departure noted by Stanley, may be interesting to teachers :—

	Date of appearance	Date of departure
Sand-martin . . .	March 27	September 21
Swallow	April 11	October 20
House-martin . . .	March 20	October 20
Swift	April 27	September 16
Redstart	April 6	September 5
Whitethroat . . .	April 6	September 8
Cuckoo	April 10	June 30
Redwing	September 26	April 3
Fieldfare	September 29	May 1
Woodcock . . .	October 15	April 2

THE OSTRICH

Where found.—The ostrich lives in South Africa. Describe the kind of country. As it is sandy the bird's long legs are useful ['*Why?*']; as there are no trees the bird does not want grasping claws or wings.

A running bird.—Legs very long and very strong. Can break a man's leg with a kick. Two toes, the outer about half as long as the inner, which has a claw.

Food.—In a wild state the bird lives chiefly on melons, which grow plentifully on the ground.

Neck.—Elicit that as the legs of the ostrich are very long and its food is found on the ground, it must have a very long neck.

Bill.—Draw on the blackboard hawk's beak, formed for seizing prey, and a hen's, formed to pick up grain. Elicit that neither of these would do for the ostrich, which has a bill something like a duck's.

Size.—From the long neck and long legs children will gather that the ostrich is a large bird. Tell them it is the largest—from 6 to 8 feet high.

Wings.—As the bird has long legs and can go faster than a horse, it does not need to fly. Wings, therefore, very small in proportion. Like a hen's, they help the bird to run.

Feathers.—Show. Though the wings are comparatively small, the feathers in them and in the tail are really large and beautiful. They are black, grey, and white, and worth a good deal of money.

Eggs.—Very large; contain as much as twenty-four eggs of hen.

Hatching.—The eggs are laid in the sand and hatched by the sun, except in the parts furthest from the equator, where the sun's heat is not enough and the birds sit on the eggs.

Hunting.—Hunted. '*Why?*' Chased by men on horses. The birds run in a zigzag line, but the horses keep straight on. Illustrate on blackboard.

FIG. 25.

Ostrich farms.—In South Africa ostriches are now reared on farms. '*Why?*' The eggs are hatched in incubators.

THE HERRING

[Illustrate the action of the gills, fins, and tail by having a gold-fish or other living fish. For the special structure have a dead herring.]

Some peculiarities of a fish.—*Gills.*—'*What do we breathe with?*' '*What passes into our lungs?*' '*What does the air do in the lungs?*' There is always a little air in the water. Show the bubbles in water which has been standing. Also boil a little water in a test-tube, and make the children observe the many bubbles of air which will rise to the surface. Fish breathe this air, but they have no lungs. They breathe by means of their gills. Show the folds in the herring's gill, and show the action of the gills in the living fish. The blood passes through the gills. '*What colour are they?*' '*Why?*' When a fish breathes it takes water through its mouth and makes it pass over the gills, and the air in the water purifies the blood.

Eggs.—Show a 'hard roe.' This is made up of the herring's eggs. '*What is the difference between the eggs of a bird and those of a fish?*' [The shell.] '*How many of you have seen the "spawn" of frogs in pools and ditches in spring?*' This is made up of the eggs of frogs. The eggs of some fish look like that.

'*What causes a hen's eggs to hatch?*' The eggs of fish are also hatched by heat, but it is the heat of the sun. By reference to the times which it would take a large kettle and a small one to boil, elicit that shallow water gets warm sooner than deep. Fish that live in the depths of the ocean lay their eggs near the shore.

Shoals.—About July or August millions of herrings appear in some of the British seas. Name the seas. They are then in the best condition for eating, and it is then that they are caught. '*Why could they not be caught in deep water?*'

Description.—Using the herring provided get the children to describe it—length, shape [Compare to racing-boat or swift ship], eyes, no lids ['*Why?*'], scales [Note how they are silvered], fins, and tail [Show use by living fish].

Fishery.—Describe the fishing as graphically as possible.

Curing.—*White herrings* are simply gutted and salted.

Other herrings are gutted, strung on sticks, and hung in a room which has fires (generally of oak) lit on the floor. If removed after twelve or fourteen hours' smoking they are called *bloaters*; if allowed to remain about twelve days they become *red herrings.*

C: Lessons on Plants

FLAX

[If this lesson is given in the summer there ought to be no difficulty in procuring specimens of the flax plant, for in those districts where it is not cultivated it grows wild among the corn. Some of the linen manufacturers are kind enough to give illustrations showing every process through which the fibre passes.]

Two uses.—Show fibre and linseed. The flax plant is grown either for its fibre, which is made into linen, or for its seed, which is made into linseed oil and oil-cake. It flourishes in cold countries like Russia, and in hot countries like India; but in the former the fibre is good and the seed nearly valueless, whereas in the latter the seed is valuable and the fibre of little use.

Where grown.—The soil best suited is one that is fairly firm and moist. This is why it grows so well in Ireland, Holland, and the flat parts of Russia.

Cultivation.—The details of this may be passed over.

Pulling.—If the flax is grown for its seeds, it is allowed to ripen; if for its fibre, it is pulled up by the roots when the plant has reached its full height. Elicit that pulling gives a greater length of fibre than cutting would.

Seeding.—The linen manufacturer does not want the seeds, so they are taken away by pulling the flax through the teeth of an iron comb. Illustrate with the fingers.

Retting.—Let the children see that the stalk is made up of a woody and of a fibrous part. The linen manufacturer wants only the fibre. To separate this from the other part, the first thing is to steep the flax in water for a week or a fortnight. The soaking rots the wood and also loosens the fibres from it, almost as soaking loosens a piece of paper that has been pasted on anything. When the flax has been steeped long enough it is taken out and dried.

Breaking and scutching.—Elicit that as the wood is now rotten, while the fibre remains tough, the one can be broken without injury to the other, and the next two processes (details of which can be ignored) break and remove the woody part, leaving the fibre entangled.

Heckling.—The fibres are passed through the teeth of a kind of comb to be straightened and arranged. The short fibres fall to the ground. These form *tow*, which is used for making twine and cord.

Spinning &c.—In this lesson the remaining processes in the manufacture of linen should be simply mentioned; but when the children are a little older they may have a lesson on spinning, weaving, &c., considered generally. This will lighten lessons on the separate materials—linen, cotton, and silk.

COTTON

What it is.—Refer to thistledown, and to the seed in the middle of each little ball. Cotton is the soft white down covering the seeds of a plant.

Where grown.—Cotton takes about seven months to grow, and, as the least frost injures it very much, it can be grown only in those parts of the world where for more than half the year there is no frost whatever. It also requires a fair amount of moisture, but too much rain is not good for it. If

is therefore grown largely in the south-east of the United States, in India, in Egypt, and in Brazil.

The plant.—The plant is from 2 to 4 feet high (about the height of a gooseberry bush). It has dark-green leaves, shaped somewhat like the leaves of the sycamore. The flower is in form very much like the single hollyhock, but is yellow in colour with a purple centre. When the flowers go off, pods appear, about the size of an apple. These partly open, showing the cotton and the seeds. Show. The seeds are about as big as a pea slightly flattened.

Cultivation.—In the United States cotton is generally planted in rows, pretty wide apart, to allow of hoeing and weeding. Where the climate is at all moist the earth is ridged up about the roots, so that when there is too much water it may drain off.

Gathering.—When ripe, the cotton is gathered by hand, and placed in baskets carried by the picker. It is then dried in the sun.

Ginning.—Before it leaves the plantation the seeds are removed by means of a gin. In India the gin consists of two rollers placed close together. The cotton is made to pass between them, and the seeds are left behind. In America a saw gin is used. This consists of a box, one side of which is made of strong straight wires so close together that the seeds cannot pass between them. Small round saws work between the wires, dragging the cotton through and leaving the seeds behind.

Bales.—The cotton is then pressed together very hard and packed in bales, which are sent to Lancashire and other places where the manufacture of cotton goods is carried on.

Manufacture.—As in the case of flax, the processes need be no more than indicated.

CORK

Bark.—Show pieces of the branches or twigs of several different trees. Strip the bark off each ; show it, and get or give the name.

Cork is the rough outer bark of a kind of oak which grows chiefly in Spain. The tree is much smaller than the English oak, being only about 30 feet high. Make the height concrete. The tree also differs from the English oak in being evergreen. Ask what that means.

Stripping.—The trees shed their outer bark sometimes, but generally it is stripped off. One cut is made round the trunk near the ground, and another just below the branches. Then several cuts are made downwards from one ring to the other. The end of a kind of bar is placed in the cut, and the cork forced off the trunk. Illustrate with a pointer or poker. Care is taken not to injure the inner bark. If that were destroyed the tree would die. The tree is first stripped when it is about twenty years old, and it is stripped again every eight or ten years.

Preparation.—'*What is the shape of each piece of cork when stripped off?*' In order to flatten it, it is placed in pits with heavy weights on the top. Illustrate. Water is then let into the pits, and the cork is left to soak for a time. It is then dried before a fire and slightly charred. This closes the pores ['*Why must the pores be closed?*'], and makes the cork keep its flatness.

Qualities and uses.—Show that it is elastic, and that water will not pass through it. Hence it is used for corks and bungs.

It is very light. Show that it floats easily, and will bear a considerable weight without sinking. Hence it is used for life-buoys ; also for 'floats' of fishing-nets.

Being light and dry, it is used for 'socks'—thin soles worn inside boots and shoes.

The shreds, mixed with indiarubber, are made into linoleum.

LEAVES

[(1) The lessons on Leaves are directed almost exclusively to the cultivation of the observing powers.

(2) The matter provided will probably prove sufficient for five lessons, but the amount to be taken at once must necessarily depend on the time allotted to a lesson.

(3) If not amply illustrated with actual leaves the lessons will be worse than useless.

(4) It follows, therefore, that the lessons should be given while trees are in full leaf.

(5) The particular leaves suggested for illustration have been selected because it is believed that they are all easy to procure. Should there be a difficulty in finding any leaf named, another, having the same botanical peculiarity, should be substituted for it.]

PARTS OF A LEAF

[Give each child

(1) Leaf with petiole and stipules, as *apple*.
(2) Leaf with petiole but without stipules, as *ivy*.
(3) Sessile leaf, as *wallflower*.
(4) Wheat (not in ear) or grass.

In the case of the first three the leaf should be on the stem, and in the case of the fourth the sheath should be present.]

The blade.—Make children hold up apple leaf and point to the blade [*lamina*].[1]

Let them do the same with the ivy, wallflower, and grass. Teach the term *blade*.

The stalk.—Make children hold up apple leaf and point to the stalk (*petiole*).

Do the same with the ivy.

Let them hold up the wallflower leaf. Ask children to show stalk. This will impress on them the absence of stalk.

So with the wheat. Show that there is no stalk as in the apple and ivy, but that there is a sheath which takes its place.

[1] The technical terms are not to be taught. They are inserted for the sake of the teacher. Some of them have no simple name corresponding, and if only a simple name made up for these lessons were inserted there might be some doubt about its meaning.

The leaf-scales (*stipules*).—Make children see that where the stalk of the apple leaf joins the stem there are two very small leaves. These are sometimes called *leaf-scales.*

Then make them see that the stipules are wanting in the ivy and wallflower.

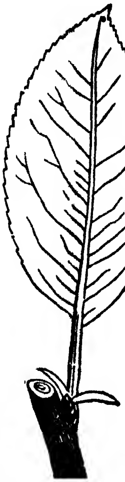


FIG. 26.—Leaf of Apple, with petiole and stipules.

FIG. 27.—Wallflower.

FIG. 28.—*a*, split leaf-sheath of a Grass; *b*, ligule; *c*, node of the culm; *d*, part of the lamina.

If the wheat (or other grass) has been well selected, the children will be able to see where the blade separates from the sheath a small scale (*ligule*).

Parts of a leaf.—'*How many parts have we pointed out in the wallflower?*' '*What is it?*'

'*How many parts have we pointed out in the ivy?*' '*What are they?*'

'*How many parts have we pointed out in the apple leaf?*' '*What are they?*'

Every perfect leaf has those three parts.

Make children see the modifications of two of them in the grass.

VENATION AND FRAMEWORK

[Give each child
(1) Beech or other feather-veined leaf.
(2) Maple or other palmate leaf.
(3) Grass or other parallel-veined leaf.]

Veins.—Let children look at beech leaf. They will see lines running along it. They will see them plainest on the under side.

[Skeleton leaves, which may often be picked up in woods or ditches, would be useful here.] These lines are called *veins*.

Let children point to veins in the maple leaf and the grass.

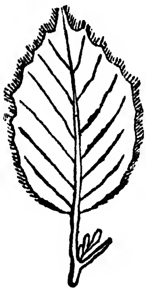


FIG. 29.- Ciliate leaf of the Beech.

Venation.—Next let them say what is the difference in the arrangement of the veins,

(1) Between the grass and the other two;
(2) Between the beech and the maple.

Teach them to call the grass *straight-veined*. [*Parallel-veined* is the botanical term, and it is just as easy as the other if the children learn drawing.]

Hold up quill pen or other feather and the beech leaf. Show similarity of arrangement between barbs of feather and veins of leaf. Hence show fitness of term *feather-veined*.

Hold up maple leaf with one hand. Beside it place the stretched-out fingers of the other hand. Make children see similarity, and hence the fitness of the term *palm-veined* (*palmate*).

Recapitulation.—Produce a number of leaves different from those used hitherto, and question on their venation which should be of the three kinds spoken of.

Mid-rib.—Show line running down middle of beech leaf. It is a *rib*. When there is, as in this case, only one, it is called the mid-rib.

Ribs.—Make children point out all the ribs in the maple leaf and see that there is no mid-rib

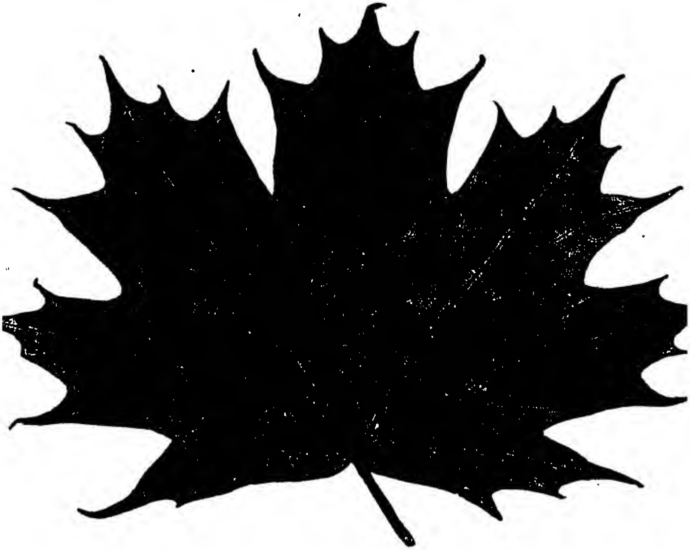


FIG. 30.—Reticulately veined leaf of *Acer acutifolium*

Veins.—Make children point out veins on beech and maple.

Veinlets.—Let the children hold the leaves up to the light. Between the veins they will see finer lines. These are called *veinlets.*

Recapitulation.—As in the case of venation.

SIMPLE AND COMPOUND LEAVES

[Distribute specimens of various compound leaves, as ash, acacia, horse-chestnut, poppy, clover, &c.

Also some simple leaf with bud at the angle where the stalk joins the stem (the *axil*).]

Simple leaf.—Show the simple leaf. Make the children see

(1) That the green matter is continuous around the ribs.

(2) That there is a bud in the axil.

Compound leaf.—Show a compound leaf (ash or acacia, say), and make the children see

(1) That the green matter is not continuous around the ribs.

(2) That there is a central stem with little leaves branching out on each side of it.

(3) That there is no bud at the axil of these little leaves.

The first kind of leaf is called *simple*, the second *compound*.

The little leaves of the compound leaf are called

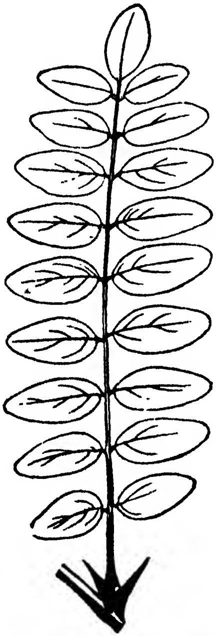


FIG. 31.—Compound leaf of Acacia, with opposite leaflets and spinous stipules.

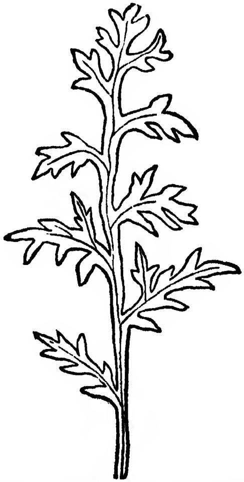


FIG. 32.—Compound leaf of Common Poppy.

leaf-lets [compare with *vein-lets*]; their stalks might be called *stalk-lets* (*petiolule*).

Some kinds of compound leaves.—Refer to feather-veined leaves. Ask children to pick out compound leaves with the leaflets similarly arranged (as acacia). These are called *feather-like* (*pinnate*).

Ask children to pick out compound leaves with leaflets arranged like outstretched fingers (as horse-chestnut). These are called finger-like (*digitate*).

Then show other compound leaves, and call attention to the arrangement of the leaflets.

Recapitulation.—Produce miscellanous leaves. Ask children to divide them first into simple and compound ; then to classify the compound.

SHAPES OF LEAVES

[Get leaves of as many different forms as possible, including grass, Guelder rose, beech, oak, endive, holly, sycamore, geranium, dandelion, thistle, lilac, ash, nasturtium, radish, or other leaves having the same characteristics. Explain that you are going to divide them into classes. The classification[1] may be fourfold, depending upon

(1) General outline.
(2) The margins.
(3) Incision.
(4) Apices.

When any leaf is shown ask the children to pick out or name other leaves having the same characteristic.]

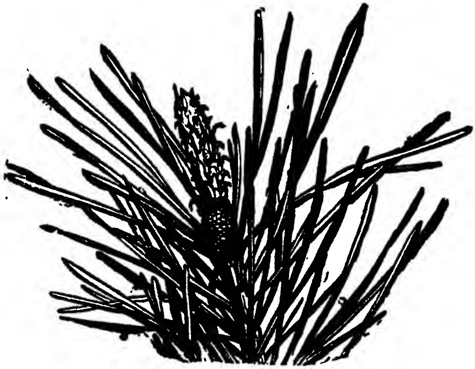


FIG. 33.—Acerose leaves of the Scotch Fir.

FIG. 34.—Lanceolate leaf of the Privet.

[1] From the teacher's point of view the classification of leaves is not of much importance, but getting children to use their eyes and to describe what they see is of great importance.

(1) **General outline.**—A few out of the great variety of outlines may be shown. Dealing with leaves easily procured, we may show outlines which are—

Sword-shaped (*ensiform* or *linear*), as grass.
Needle-shaped (*acerose*), as pine.
Lance-shaped (*lanceolate*), as privet or willow.
Shield-shaped (*peltate*), as nasturtium.
Egg-shaped (*ovate*), as a rose.
Heart-shaped (*cordate*), as lilac.
Hand-shaped (*palmate*), as maple or sycamore.
Feather-shaped (*pinnate*), as ash.
Lyre-shaped (*lyrate*), as radish.

(2) **Margin.**—The margin may be smooth (*entire*), as in grass or iris.

It may be tooth-like (*dentate*), as in the Guelder rose.

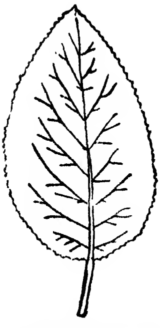


FIG. 35.—Dentate leaf of Guelder Rose.

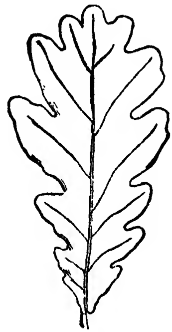


FIG. 36.—Sinuate leaf of the Oak.

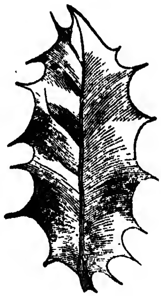


FIG. 37.—Spiny leaf of the Holly.

It may be hairy (*ciliate*), as in the beech (Fig. 29).

It may have rather large hollows between rounded parts (*sinuate*), as in the oak.

It may be *crisped*, as in the garden endive or curled dock.

It may be *spiny*, as in the holly.

(3) **Incision.**—This subject is rather too difficult for young children. Show them a few examples of incised leaves, as hop, sycamore, passion-flower, geranium, dandelion, thistle.

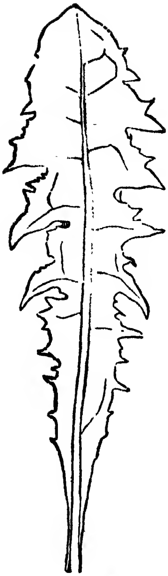


FIG 38.—Leaf of Dandelion.

FIG. 39. · Leaf of *Geranium pratense.*

(4) **Apices.**—The points of the leaves are of different shapes. Call attention to the points of the leaves produced, and make the children describe the shapes.

EDIBLE LEAVES

As a summary of the preceding lessons on Leaves a lesson may be given on Edible Leaves. Get from the children a list of the leaves eaten cooked, such as rhubarb, the many varieties of cabbage, turnip-tops ; and the leaves eaten in salads, as lettuce, endive, 'mustard and cress,' &c. Have specimens of each kind of leaf spoken of, and question as to its botanical characteristics. Ask for the blade, stalk, and leaf-scales, ribs, midrib, veins, veinlets, the venation and framework, margins, outline, &c. Also ask what other leaves with the same characteristics the children have seen.

If drawing is taught, the outlines and venation of leaves should form subjects of two or three lessons.

TEA

Leaves.—Show the class some leaves that have been taken from a tea-pot and stuck on white card. The size and shape will thus be seen.

Where grown.—'*On what did these leaves grow?*' '*Which of you has seen a tea-plant?*' [No one.] '*Why not?*' It grows in China, the North of India, and Ceylon. Show on the map.

The shrub.—Show a picture. If there is not one in the school one can probably be obtained from some advertising tea-dealer. Failing this, draw sketch on the blackboard with coloured chalks.

The shrub is an evergreen. '*What does that mean?*' '*Name some evergreens that you know.*'

It is from three to six feet high. Show height. It would grow higher if it were not cut down. '*Why is it cut down?*' [To get more leaves and less wood.] To make this clear get out why a quickset hedge is frequently cut down.

If the children have seen a myrtle say that the shrub resembles it. The leaves are of a bright deep green, and the flowers are a good deal like those of the camellia.

The gathering.—The leaves are first gathered when the shrub is three years old There are three gatherings in the year—in spring, summer, and autumn. Recall the fact that the shrub is an evergreen. The spring crop is the best, and the autumn crop the worst.

The leaves are gathered one by one by people wearing gloves. '*Why are gloves worn?*' Fold a piece of paper, place some juicy leaf between the folds, and squeeze; then open the paper and show that the leaf is crushed and the juice gone. The tender tea-leaves might be crushed if gathered with the naked hand.

The drying.—'*Who has turned over a heap of leaves?*' Thence get out that the lower *leaves were rotting*. If the tea-leaves were sent to this country as gathered they too would rot.

The leaves are dried in a flat iron pan on the top of a kind of stove. Illustrate by drying some leaves on a hot shovel or other metal plate, and show that if they were not stirred they would shrivel up.

When the leaves are hot they are poured on mats placed on a table. Then they are rubbed with the hands in one direction to make them curl. Illustrate with the leaves already dried. Show some tea, and let children note similarity. The roasting and rubbing are repeated several times till all the moisture has gone. Then they are ready for use.

Kinds.—'*How many kinds of tea do you know of?*' The black tea consists of the older leaves. They are placed in a heap after they are gathered, till the heat thus formed darkens them. [If the lesson is given to rural children compare to the 'heat' of a new hayrick, and call attention to the difference in colour between grass and hay.]

Green tea consists of the younger leaves dried and rolled as soon as gathered.

Poor kinds are dyed.

TOBACCO

[Tobacco is often grown as an ornamental plant. If the teacher knows any garden where it is so grown he should procure a leaf or two. A dried leaf can be obtained at a tobacconist's.]

Forms.—Show the leaves, and say what they are.

(1) The leaves are cut for smoking in pipes and cigarettes.

(2) They are folded for smoking as cigars.

(3) Certain parts of them are dried and ground for snuff.

Where grown.—Tobacco was first brought from America, where it is still largely grown. It will grow in any country where they do not have sharp frosts. '*What would frost do to it?*'

Growth.—Compare the first stages in the cultivation of the tobacco plant to the first stages in the cultivation of cabbages. The seeds are set in hot-beds. When the plants are about four

inches high they are transplanted. '*Why?*' [For light, air, and room to grow.] Till the warm weather comes they are covered at night. '*Why?*'

The fields are carefully weeded. Decaying leaves are plucked off. The flower is also cut off. Explain that this gives greater strength to the leaves.

Harvesting.—When the leaves become of a yellowish-green they are ready to be harvested.

The plants are cut close to the ground, and hung up in barns for about a month to dry. Then they are piled in a heap to sweat.

The leaves are now tied into bundles called *hands*, packed in hogsheads, and sent to the place where they are to be prepared for use. [The details of the manufacture can be ignored.]

Moral.—Many people believe that tobacco is harmful to everybody. There can be no doubt that it is very harmful to all persons who are not full grown.

THIRD YEAR

A: Lessons on Elementary Chemistry and Physics

OXYGEN

[**Hints to the teacher.**—Oxygen may be made by heating chlorate of potash (potassium chlorate) or black oxide of manganese (manganese di-oxide); but it is best prepared for experimental purposes by using a mixture containing about equal weights of the two substances, as the gas comes off at a much lower temperature than when either is used alone.

Place the mixture in a flask (as shown in the following cut) or in a glass retort. The flask must be provided with a cork through which a bent glass tube passes. Nearly fill a pneumatic trough with water, and above each hole in the shelf of the trough place an inverted jar filled with water.

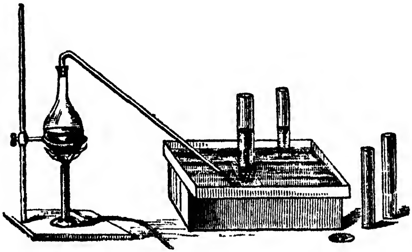


FIG. 49.

Place the bent end of the delivery tube under water (not under any of the jars), and apply heat to the flask. The bubbles at first given off consist of the air driven out by expansion. When all the air has come off, place the tube under the first jar. When that is full, place the tube under the second jar. While that is filling, cover the mouth of the first (under water) with a greased

glass disc. Proceed thus till as many jars are provided as will be required.

If the teacher has no proper flask or retort, the 'Florence flasks' in which olive oil is sold offer a satisfactory substitute. See that they are without flaw, and choose the thinnest. If a thick one is used, the heat may crack it by expanding unequally the inside and the outside.

The cork must fit exactly. To make sure of its being air-tight, rub a little grease around the edge of the flask after the cork has been inserted.

The hole for the glass tube is best made by means of cork-borers—small brass tubes, the lower ends of which are sharpened. Select a borer which is a shade less in diameter than the tubing to be used, and, if necessary, clear it with the rod provided for the purpose. Begin at the small end of the cork, and take care that the hole is made straight.

There is no satisfactory substitute for the borer. Perhaps a small pointed triangular file is the least unsatisfactory. First push an awl straight through the cork, and then enlarge the hole with the file, making the tubing in the cork air-tight with grease.

The best way to bend glass tubing is to hold it horizontally in a gas-flame from an ordinary burner the long way of the flame.

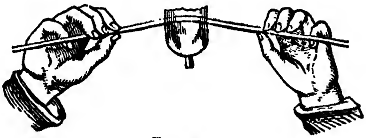


FIG. 41.

Keep twisting it round till it begins to soften, and then let it bend over to the right shape by its own weight.

To cut glass tubing make a notch in it with the triangular file, then bend it away from the notch, pulling at the same time. The sharp edges can be rounded off by making them red-hot.

If the teacher has no proper gas-jars, large-mouthed glass fruit or pickle bottles will do very well instead; but the mouths must, if necessary, be ground flat. To do this, get a piece of plate glass 6 or 8 inches square; place on it some fairly coarse emery and some water. Hold the bottle mouth downward on the plate, and rub hard with a circular motion. When collecting gas, grease the glass plate to make it air-tight.

A cheap form of pneumatic trough (shown in the following cut) consists of an earthenware basin with a little stand, called a bee-hive shelf.

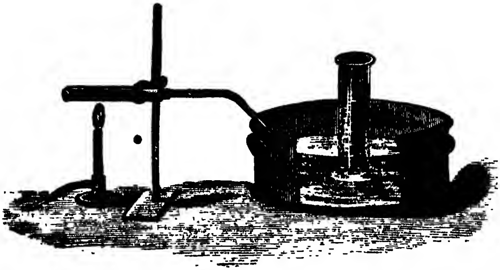


FIG. 42.

Failing any form of pneumatic trough, a flat-bottomed pan having an improvised shelf with perforated holes may be used.

The risk of breaking the flask may be reduced if the mixture is first warmed gently at the top, and the flame is brought gradually downward as the gas begins to be given off.

As soon as the jars of gas are full, lift the end of the delivery tube out of the trough. Otherwise, as the hot gas cools and contracts, the water will rush up the tube and crack the flask.]

A gas.—If the gas is laid on, turn the tap, but do not light the gas. '*What is coming out here?*' There are many different kinds of gas, and this is called 'coal-gas.' '*Can you see it?*' '*Can you smell it?*' '*Can you feel it?*' (Only when it is in motion.) '*Will it burn?*' Light it for a moment.

But for the little coal-gas now in it, the room is full of other gases. '*Can you see them?*' '*Smell them?*' '*Feel them?*' '*Will they burn?*' Light a match to show that they will not. These gases together make up the air. One of them is called *oxygen.*

Some properties of oxygen.—Show the jars containing oxygen. Make the children perceive that it has no colour, smell, or taste. Warm the oxygen mixture a little, and let the gas escape into the air. Apply a match to the end of the delivery tube. The gas will not burn. Tell the children about some people being suffocated while sleeping in a room into

which coal-gas was escaping. That proved that we cannot breathe coal-gas. We can breathe oxygen; in fact, we should very soon die if we had none to breathe.

Things burn in oxygen.—Many experiments can be performed to show that things burn in oxygen better than they do in air.

(1) Light a splint of wood. Blow out the flame, but leave a glowing spark. On being dipped into a jar containing oxygen this spark bursts out into a flame.

(2) Show that it is difficult to burn charcoal in air. Then put a piece on a deflagrating spoon, as in Fig. 43; ignite, and place in the oxygen. The charcoal will at once glow brightly and throw off brilliant sparks. [A piece of wire, one end of which is passed through a cork and the other twisted around the charcoal, will do instead of a deflagrating spoon.]

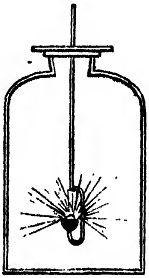


Fig. 43.

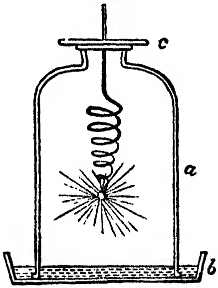


Fig. 44.

(3) Burn sulphur similarly in air and in oxygen.

(4) Show that a piece of iron wire will become red-hot in air, but will not burn. Dip the red-hot end in oxygen, and the iron itself will burn brilliantly (Fig. 44).

Other similar experiments may be performed if the apparatus and materials are available, but the teacher must take care to impress upon the children the truth which the experiments illustrate.

Things will not burn without oxygen.—Things burn in the air because of the oxygen in it. As they burn they use up the oxygen, and when it is all used they go out.

Stand a lighted candle in a shallow dish. Over it place a bottle or jar, and pour into the dish enough water to cover the mouth of the jar or bottle, and thus prevent the entrance of air. When the candle has used up all the oxygen it will go out.

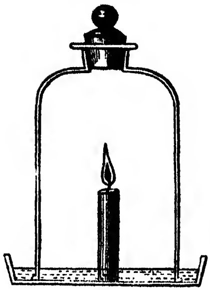


FIG. 45.

If instead of the bottle we had a bell-jar (as in Fig. 45), we could lift the stopper and re-light the candle. Then if we admitted air below by means of a tube, the candle would continue to burn. [A fruit or pickle-bottle from which the bottom has been removed is a satisfactory substitute for a bell-jar.]

NITROGEN

Revise the last lesson so far as may be necessary to re-impress on the children's minds—

(1) That the air is almost entirely made up of two gases.

(2) That oxygen is one of these.

(3) That some of the oxygen is used up when anything is burned.

Nitrogen.—[For the success of this lesson a bell-jar (or some such substitute for one as was suggested at the end of the preceding lesson) is essential.] Take a piece of phosphorus about as large as a pea; dry it with blotting-paper, and then place it on a large piece of cork floating in a shallow dish containing a little water. Cover with a bell-jar. Remove the stopper, ignite the phosphorus with a piece of red-hot wire, and *immediately* replace the stopper. The jar will be filled with dense white fumes. When these have settled it will be seen that the water has risen some way in the jar. Measure, and prove that it has risen one-fifth. '*With what was the jar filled at first?*' '*And of how many gases was this air made up?*' '*What is the name of one of them?*' '*What became of this as*

the phosphorus burned?' 'Why did the phosphorus go out? 'How many gases are there now left in the jar?' 'What took the place of the oxygen?' The other gas is called *nitrogen*, and it forms four-fifths of the air.

FIG. 46.

Properties. — Pour water into the vessel till it reaches the level of that inside the jar. Make the children perceive that the gas inside the jar has no colour [Should there be any colour it is caused by the fumes of the burning phosphorus], smell, or taste. Place a small lighted taper in the nitrogen. It at once goes out, thus showing that things will not burn in nitrogen.

Contrast the properties of oxygen and nitrogen. Remind the children of the great rapidity with which things burned in oxygen. Hence elicit the

Use of nitrogen. If the air were made up of oxygen alone it would be too strong for us to breathe. We should be used up as fast as things are burned up in it alone. Hence the necessity for 'diluting' the oxygen with nitrogen. Compare to the way in which mother adds water to tea which is too strong.

CARBONIC ACID GAS[1]

[The apparatus required for the preparation of carbonic acid gas is shown in fig. 47.

An ordinary fruit or pickle bottle will do, if fitted with a large cork. In the bottle place small pieces of chalk, limestone, marble, or any other carbonate. To this add hydrochloric or some other acid.]

Properties.—(1) Dip a burning taper or candle into a jar containing the gas. The light will go out. This proves that things will not burn in it.

[1] The name which chemists now give this gas is *carbon di-oxide.* This has the merit of indicating the composition, CO_2.

(2) Take a jar containing only air. To show that it contains air place a lighted candle in it. Pour into it the carbonic acid gas, and prove that you have done so by again placing the lighted candle in. This shows that carbonic acid is heavier than air—which also is proved by the method of collecting the gas.

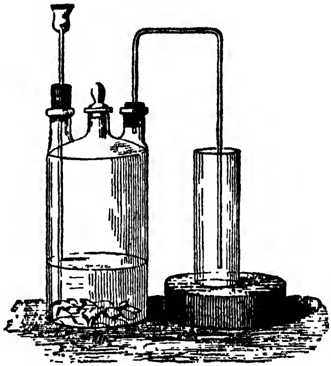


FIG. 47.

(3) Pour a little lime water[1] into a jar. Introduce some gas into the water, which turns milky. Make the children note this carefully, as this is the test for carbonic acid.

We breathe out carbonic acid gas.—Let some of the children breathe through a tube into some lime-water, which will become milky. *'What does this show?'*

There is a little carbonic acid gas in the air.—The experimental proof of this cannot be performed in the course of a lesson. If some lime-water be exposed to the air for a day a thin film will form on the top, and in a few days it will be milky. This proves that the air contains the gas, but contains very little. It really forms four parts out of 10,000.

Carbonic acid gas is formed when things[2] burn.—Place a candle in a bottle containing carbonic acid gas. When the candle has gone out, pour a little lime-water in and shake it up. It turns milky.

Food for plants.—Plants help to purify the air, because they take from it and use for food the carbon or carbonic acid [*'What remains?'*], and they give out oxygen. (See p. 232.)

[1] If lime-water cannot be readily procured, prepare some by putting a piece of common lime about the size of a hen's egg in a quart of water, allowing it to remain there three or four hours, and then filtering the liquid through filter-paper placed in a funnel.

[2] Strictly speaking, when carbonates burn.

HYDROGEN

[**How to prepare.**—Hydrogen is generally prepared in a Woulffe's bottle, as shown in Fig. 48.

If there is not one available use a wide-mouthed bottle, and bore two holes in the cork, one for the thistle funnel and the other for the delivery tube. The whole apparatus must be made air-tight.

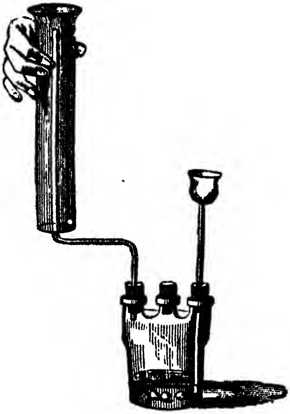


Fig. 48.

Place in the bottle about an ounce of zinc cuttings or zinc nails. Cover them with water. Then through the thistle funnel, pour in a little sulphuric acid, and hydrogen is given off through the delivery tube. Keep the apparatus at a distance from any flame.]

Properties.—(1) We collect the gas by placing a test-tube *over* the delivery tube. Make the children see that this shows the gas is lighter than air. It is the lightest gas known.

(2) Connect an ordinary clay pipe with the delivery tube by means of indiarubber tubing. Dip the bowl into a solution of soap so that the gas may blow a bubble. This, when detached, rises rapidly into the air. Show how much slower a bubble blown with the breath rises. A small balloon made of gold-beaters' skin will rise if filled with hydrogen.

(3) If the end of the delivery tube has been made small by holding in a flame, apply a light to it. The gas burns with great heat but little light.

(4) Fill a test-tube with hydrogen. Apply a light. There is a loud explosion and the gas burns. A mixture of hydrogen and oxygen, or of hydrogen and air, is explosive.

(5) After the last experiment look at the tube. Its sides

are wet. The burned hydrogen and the oxygen necessary for burning it formed water. Water consists of one part of oxygen and two of hydrogen.[1]

A BURNING CANDLE

What does not burn.—Light the candle. '*Of how many parts is this candle made up?*' '*Which of them is burning?*'

Apply a light to fat without wick and to wick without fat, and thus show—

(1) That the fat will not burn at all, and

(2) That the wick burns badly for a very short time and then goes out.

What does burn.—Place a little fat in an evaporating-dish or watch-glass; warm till vapour arises, then light the vapour. '*What is burning?*'

Light the candle. Blow it out. Apply a match to the smoky vapour arising, being careful that the match shall not touch the wick. The vapour will light and communicate flame to wick.

When a candle is first lighted the heat of the burning wick forms a little cup containing melted fat. The wick sucks up this fat, which the heat changes into vapour that burns. '*Why does a candle, when first lighted, nearly go out sometimes, and then flame up suddenly?*'

The flame.—Place lighted candle under tumbler or other glass vessel. Candle goes out. '*Why?*'

Burning goes on only in contact with oxygen. The flame is therefore hollow. The shape of the flame will best be seen if a lamp-glass is placed over the candle. The glass must be so placed as to admit air below, or the candle will go out.

To show that the flame is hollow take a piece of white paper; hold it, with the surface horizontal, in the middle of the flame; remove before ignition takes place; rub off the soot, and a scorched circle will be seen.

[1] The fact that the two gases must be *chemically*, not *mechanically*, combined, may be ignored at present.

The hollow of the flame is filled with gas which will burn.

Hold one end of a glass tube very steadily in the lower part of the flame; apply a light to the other end, and the gas from the hollow of the flame will then burn.

What becomes of the candle.—The fat of the candle is made up chiefly of hydrogen and carbon. The hydrogen uniting with the oxygen of the air forms water.

Hold a glass vessel over the flame, and water will be deposited on the sides. The vessel must not be held too long or the heat of the candle will dry up the water.

The carbon of the candle uniting with the oxygen of the air forms carbonic acid gas. *Show* them that the gas given off by the candle does the same, thus:—

Show this by letting the candle burn out under an inverted fruit-jar or other glass vessel, and then pouring a little lime-water into the vessel and shake.

The bright part of the flame consists of burning carbon. Some of this carbon is given off as soot. Show. The 'smoke' consists of particles of carbon.

MATCHES

Tinder.—Before matches were invented there were other ways of getting a light. One was the tinder-box.

Prepare some tinder, and procure a piece of flint and a piece of steel. [The back of a pocket-knife will do well for the steel.] Strike sparks, and let them fall on the tinder. Show that it will glow, but not flame.

Sulphur matches.—The difficulty of obtaining a flame was got over by touching the glowing tinder with something that would easily light, such as a sulphur match.

Prepare sulphur matches by melting a little sulphur and dipping into it the ends of dry splints of wood. [The wood of ordinary matches will do.] Touch the glowing tinder with one of the sulphur matches.

Chlorate of potash and sugar.—Matches were also made

by dipping the ends of splints into a mixture of chlorate of potash, sugar, and gum. '*Why gum?*' [To make the mixture stick to the wood.]

Prepare matches as described, or drop a little sulphuric acid on a mixture of powdered chlorate of potash and sugar.

The matches were lit by dipping them into sulphuric acid.

Phosphorus.—These methods of getting a light fell out of use when phosphorus matches were invented.

Friction causes heat, and the heat, if great enough, causes flame.

(1) Let a child rub a brass button on the desk. '*What makes the button hot?*'

(2) '*When a train is going very quickly the wheels or axles sometimes get on fire. Why?*'

(3) '*How do savages get a light?*'

Phosphorus lights with very little heat.—Show bottle containing phosphorus. '*What is the liquid in the bottle?*' [Water.] '*Why has the phosphorus to be kept under water?*' '*Why do we rub a match?*' [The friction gives heat enough to make the phosphorus light.]

Phosphorus matches.—The heads of matches are now generally made of a mixture of phosphorus, chlorate of potash, sugar, gum ['*Why gum?*'] and colouring matter.

Safety matches.—Rub an ordinary match on anything rough. '*What causes it to light?*' [The phosphorus.]

Rub a safety match. '*Why will it not light?*' [There is no phosphorus in it.] Rub it on its own box. It lights because there is a little of a kind of phosphorus on the box. Rubbing causes enough heat to make the phosphorus light the match, though not enough to light the phosphorus itself. Let a child feel that the box is warm immediately after being used.

Fusees.—'*What are these used for?*' '*Where are they used?*' '*Why would not ordinary matches do?*' Show that the end of a fusee is the same as the end of another match; then comes the head. Strike one, and make the children note that the first part flames and the rest glows. The glowing part consists chiefly of nitre (saltpetre).

Prepare 'touch-paper' by steeping brown paper in a solution of nitre and then drying well. Show the paper will glow, but not flame.

COAL-GAS

How obtained.—Fill the bowl of a clay pipe with coal-dust, cover the top carefully with well-kneaded clay, then place in a clear fire. At first, what looks like dense smoke will come through the stem. This is chiefly steam. Then will come off gas which can be lighted.

Another way is to heat coal-dust in a small flask made of hard glass, and to collect the gas over water.

When the manufacture is conducted on a large scale, the coal is heated in retorts of iron or fire-clay, and the gas is purified before passing into the gas-holder (or gasometer) where it is stored.

Properties.—These may be demonstrated from the gas in the pipes.

(1) Coal-gas will burn.

(2) It has a disagreeable smell.

(3) It cannot be breathed. Refer to cases where persons have been suffocated by an escape of gas into the room in which they were sleeping.

(4) Mixed with air it explodes. Show that the pure gas will not explode—it only burns. When there is an 'escape' the gas mixes with the air, and if a light is then brought there is an explosion.

Explosions often occur in mines from this cause.

Safety-lamp.—To prevent these a safety-lamp is used. Turn on the gas without lighting it. Over the escaping gas hold a piece of fine wire gauze. Apply a light above the gauze. The flame will not pass through it to the burner.

In a safety-lamp the flame is surrounded by fine wire gauze. By reference to experiment show the action of the lamp.

Caution.—Never seek for an escape with a light. When there is a smell of gas in a room, open doors and windows wide.

Coke.—Break the bowl of the pipe used at the beginning of the lesson. Show the coke which has been formed. Also show

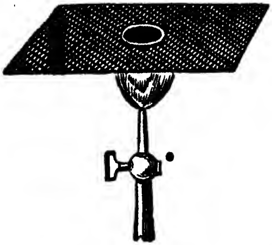


FIG. 49.

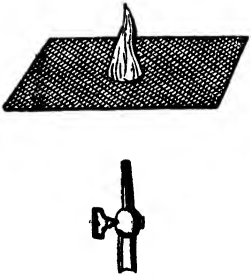


FIG. 50.

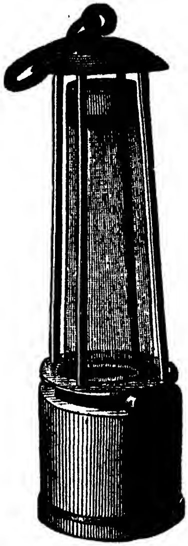


FIG. 51.

coal, and compare the qualities. '*Why does coke burn with little flame?*'

VENTILATION

Carbonic acid gas is a poison.—Refer to the Black Hole of Calcutta, and explain that the people confined in it died through having to breathe in again and again the carbonic acid gas which they had breathed out.

Also refer to cases in which people have been suffocated through sleeping in unventilated rooms in which charcoal was burning. The charcoal (carbon) combining with the oxygen of the air made carbonic acid gas.

The amount of carbonic acid gas in the air is 4 parts in 10,000; air containing 6 parts in 10,000 is 'stuffy' or close.

Products of combustion.—We saw (p. 137) that carbonic acid gas is also made when things burn. But burning things also give off tiny particles of carbon or soot. When a fire is first lit, or when it is smoking, we can see large quantities given off, but the particles are also given off when we cannot see them.

Hold over a lighted lamp or candle, too far off to char it, a piece of clean paper, and show the discolouration which immediately takes place. *'What caused the blackness?'* *'Why are ceilings often black?'*

Recapitulate and emphasise the cardinal facts—

(1) That living creatures poison the air of a room.

(2) That a lamp, a candle, or gas poisons the air; and hence show the need for getting the impure air out of rooms and pure air in.

Hot air rises.—Light a lamp which has a chimney. Let the children feel the hot air coming out at the top. Over the top hold a piece of smouldering brown paper. *'Which way does the smoke go?'* *'Why does it rise?'* *'Why does the gas blacken the ceiling and not the walls?'*

Get a wide-necked bottle, such as a jam or pickle bottle. Into the neck fit a cork with holes bored in it for two glass tubes. In the bottle place a short piece of lighted candle. Push the lower end of one glass tube down nearly to the bottom of the bottle, and let the lower end of the other tube be near the top. The hot air rises to the top of the bottle, and goes out through the upper tube. To prove this, hold a piece of smouldering paper above the tube, and the smoke will rise. Hold the paper over the other tube, and the smoke goes down and through it. *'What does that prove?'*

Insist on the two principles here illustrated, as they involve the theory of ventilation and of winds also.

Ventilation.—The air in a room could be easily changed by having one opening near the top for the hot, impure air to go out, and one near the bottom for the cold, pure air to come in.

Open the door an inch or two if it leads to a room or passage

colder than the class-room. Hold a lighted candle near the top and the flame will be blown outward ; hold the candle near the ground and the flame will be blown in. This shows the direction of the air currents above and below.

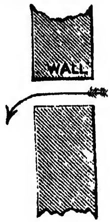


Fig. 52.

Let the children feel the cold air coming in below. They will then appreciate the objection to ventilating a room by openings near the floor —the draught caused.

If an opening is made above people's heads straight through the wall into the open air, the cold air will pour in and fall down in a stream a short distance from the opening (Fig. 52).

Hence elicit the necessity of giving the incoming air an upward direction, so that it shall come down like a fountain, after being warmed by the air near the top of the room.

This is done in several ways—e.g.—

(1) By raising the lower sash of a window and placing a board right across the lower opening. The air thus enters

Fig. 53.

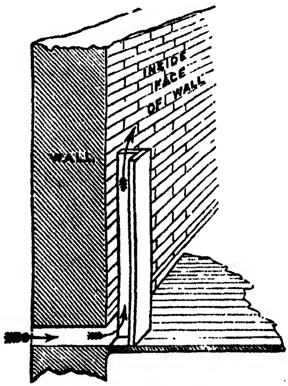


Fig. 54.—Tobin pipe.

between the two sashes, and is directed upward by the top of the lower one (Fig. 53).

(2) By fixing a Tobin pipe. Fig. 54 shows the action of this.

There are many other ways, but these two show the principles applied in ventilation.

WINDS

Hot air rises.—Repeat the experiment performed last lesson (p. 144) of burning a candle in a bottle fitted with two tubes, and emphasise the truths it illustrates—

(1) Hot air rises.

(2) Cool air flows in to take its place.

Further illustrate the same truths by reference to a fire in a grate. When the fire is lit it begins to warm the air around it. This air goes up the chimney, carrying the particles of smoke with it. Cold air from the room then flows in underneath the grate. '*Why is the grate raised above the ground?*'

The sun is to the air of the whole earth what a fire is to the air in a room.[1] By heating the air and causing it to rise in one part of the earth, the sun makes currents flow in from colder parts. These currents are called *Winds.*

Land and sea-breezes.—The effect of the sun in causing winds may often be noticed at the sea-side in summer. In the morning a breeze will be felt blowing towards the sea, and in the evening a breeze from the sea.

The land gets hot much sooner than the water. The stones on the beach will on a sunny day be almost too hot to touch, while the sea will be pleasant to bathe in. On the other hand, the water keeps its heat much longer than the land.

Towards evening the land will have heated the air above it so much as to make currents set in from the sea.

At night, however, the land rapidly loses its heat, so that in the morning the air over the water is the warmer, and currents blow towards the sea.

[1] The fact that the air is warmed chiefly by radiation, not by the direct heat of the sun, may, at this stage, be ignored.

Trade winds.—Show a globe. Ask the children to point to the warmest part of the earth and the coldest parts. Make them see that the air at the equator must rise, and the air from the poles must flow in to take its place. Hence we should expect winds towards the equator. There are such winds blowing steadily throughout the year. As sailors can always count on them they are very useful for trade, and are therefore called the *Trade Winds*. Those on the south of the equator are the *South-east* Trade Winds, and those on the north the *North-east*.

[1] '*What part of a wheel goes round fastest?*' Revolve the globe, and ask what part moves fastest. Air at the poles, therefore, does not go round so fast as that at the equator, and air from the poles comes to a part of the earth moving quicker, and so gets left behind. Hence, as the earth turns round from west to east, the Trade Winds are north-east and south-east, not due north and south. This point may perhaps be made clearer by drawing a chalk line vertically on the surface of a revolving globe. Though the motion of the chalk was vertical *in space*, the line is oblique *on the globe*.

Constant winds can be expected only when there is constant heat in the same part of the earth. There can be no constant winds in the British Isles, for example, because the temperature of the neighbouring seas and countries varies so much that currents will be blowing sometimes in one direction and sometimes in another.

RAIN AND SNOW

Evaporation.—Warm some water in a test-tube. '*What is this above the mouth of the tube?*' [Vapour or steam.] '*Where does it come from?*' Thus, though we cannot see it, there is some in the tube. Hold a lighted taper in the visible vapour, and it then becomes invisible. Hence elicit that we can see vapour only when it is beginning to cool.

If steam be watched coming out of the spout of a kettle a

[1] Omit this paragraph if the lesson is given to a dull or backward class.

small space near the spout will be noticed with no visible steam. Ask the children to explain this.

Condensation.—Over the vapour issuing from the test-tube hold a cold slate. Show the condensation into large drops of water. Then emphasise the three facts—

(1) Heat changes water into vapour.

(2) Cold changes the vapour back into water.

(3) Vapour becomes visible as it begins to cool.

The sun causes vapour to rise from the oceans, seas, lakes, rivers, and other pieces of water on the face of the earth. After a shower we say that the water on the road 'dries up.' '*What becomes of it?*'

Mist, fog, clouds.—When the vapour in the air touches the cold sides of hills or mountains, or when it comes against a cold current of air, it begins to condense. If it condenses

Fig. 55.

near the ground we call it mist or fog, and when high in the air clouds.

Rain.—If condensation goes on after the cloud is formed, the small particles of water gather more moisture around them

till at last they are too heavy to remain in the air, and fall to the ground as rain-drops.

Snow.—When the air passing through a cloud is cold enough to change the water into ice, it falls (if it falls at all) as snow.

B: Lessons on Reptiles and Invertebrata

THE FROG

[This lesson should be given at a season when it can be illustrated with a living frog. If given in the spring it should also be illustrated with spawn and tadpoles.]

Cold-blooded.—Let children feel the frog, so that they can perceive that it is very cold. '*You have heard people say that their feet were as cold as —— ?*' [Frogs.] Question as to the differences perceived in feeling (say) cat, dog, hen, rabbit on the one hand, and fish and frog on the other. The cat, dog, hen, and rabbit are warm-blooded, and need coverings to keep in the heat of the body; the fish and frog are cold-blooded, and need no such coverings.

Fish and reptiles.—The frog is a *reptile*. '*Fish and reptiles are alike in being —— ?*' [Cold-blooded.] They differ in their way of breathing. Fish breathe by means of gills, and cannot be drowned. Reptiles breathe by means of lungs, and can be drowned.

Fish and reptiles both lay eggs [*spawn*] which are hatched by the heat of the sun.

The frog at first lives the life of a fish, and afterwards that of a reptile.

Development.—The eggs are laid in the water. At first they are very small, but they soon swell to the size of a pea, and a mass of white jelly forms around them. [If possible show spawn.]

When the egg has been in the water for some time it breaks, and a little creature with a large head, long flat tail, and no

body comes out. (Fig. 57, III.) This is called a *tadpole.*[1] It swims just like a fish, by moving its tail from side to side.

It also breathes like a fish, by means of gills, which are small tufts of soft pink threads on each side of the head. (Fig. 57, III, *ex. br.*)

When the tadpole is full-grown the gills become small, and at last disappear. By this time lungs have grown in the chest, so that the creature can breathe in the air and not in the water.

Then the body grows large and the tail shrinks.

Finally, four legs grow out of the body, the tadpole has become a frog, and it leaves the water.

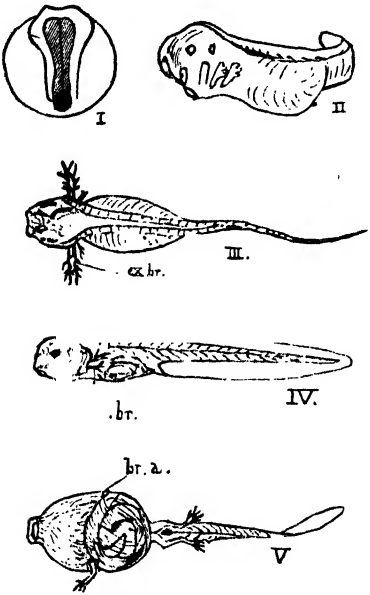


FIG. 56. – Stages in development of Tadpole.

Structure of frog. –*Legs.*—The front legs are short ; the hind legs strong and very long. Ask for other animals with long hind legs, such as kangaroo, hare, rabbit, greyhound. Show that these, like the frog, can jump well. In France the hind legs are eaten.

Feet.—Webbed. '*Why ?*' Ask for other creatures with webbed feet, and show that, like the frog, they can swim well. Still, they pass nearly all their time on land because

(1) They find their food there.

[1] A tadpole is literally a *toad-poll*—a toad which is nearly all *poll* or head.

(2) They can be drowned, and numbers are sometimes found drowned in wells and ponds with steep sides. '*Why?*'

Tongue.—Frogs live on worms, grubs, and flies. Hence they are very useful in a garden. The mouth is very wide, and the tongue, which is long and thin, is fixed near the front of the jaw, with its tip directed backwards. The tip is always covered with a sticky substance. The frog darts out its tongue, the fly or other insect sticks to it, and is drawn in very quickly.

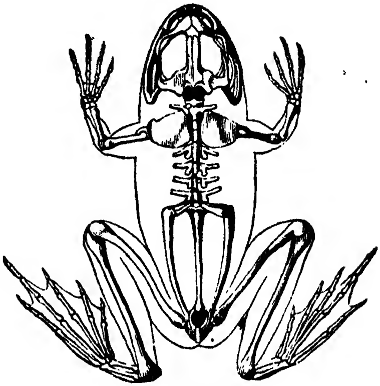


FIG. 57.—Skeleton of Frog.

Eyes.—Large; formed for seeing in the dark. '*Why is this useful to the frog?*'

Skin.—The skin of the frog is very porous and requires to be kept moist, as it shrinks rapidly if dry. Breathing takes place partly through the skin.

The winter.—Elicit that as there are no worms, grubs, or flies to be found in winter, the frog must either go to a warmer country, like the swallow, or sleep, like the bear. It sleeps. It finds out a hole in a small cave, or under a big stone, or under a bank, and there passes the cold months. Such a hole is often full of frogs.

THE CROCODILE

[The lizard resembles in many respects a miniature crocodile; one would be useful for illustration. Have also a good picture. The differences between the crocodile and the alligator can be ignored.]

Where found.—The crocodile is found in the Nile, the Ganges, and other large rivers of Africa and India. A kind of

crocodile called the alligator is found in the large rivers in the hottest parts of America.

Size.—The crocodile is the largest reptile now found in the world. From 16 to 18 feet long is a common size, but some have been known 30 feet long. Make these measurements concrete. A large crocodile weighs as much as an elephant.

Colour.—A crocodile lying on the water escapes notice because its shape and colour make it look like a floating tree-trunk or big log. Compare this 'protective colouring' to that of the lion (sand) and of the tiger (jungle grass).

Skin.—The skin of the upper part of the body is covered with thick horny scales. These are so hard that no sword can cut or spear pierce them, and bullets

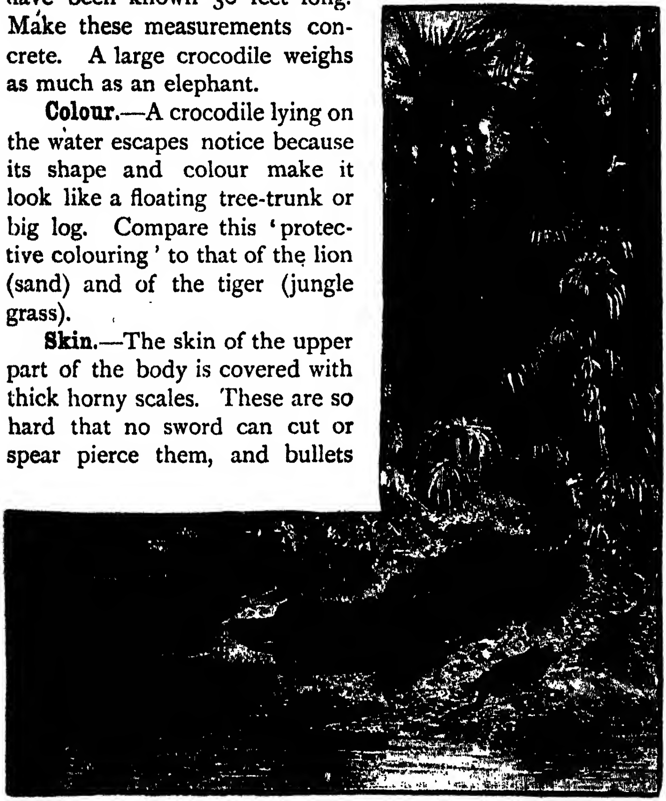


FIG. 58.

are sometimes flattened against them. The skin under the body is softer. Savages use the skin for shields and armour.

Tails.—The tail is very long and powerful, and by means of it the animal can move very quickly in the water.

Legs.—The legs are short. In the water they are used to balance the body. When angry the crocodile moves quickly on land, but its great length causes it to turn slowly, and the creature that it is chasing can escape by going zig-zag. Illustrate on the blackboard.

If the stream in which a crocodile is living dries up [Ask about the climate of the countries where it is found], the creature sometimes walks over land in search of water, but its feet are soon cut and wounded so that it can hardly crawl. Sometimes it merely buries itself in the mud of the river-bed and sleeps till the next rainy season. If the weather is very hot and dry the mud becomes as hard as brick, so that the crocodile cannot move. The natives then come and kill it at their ease.

Teeth and food.—Make the children observe the great length of the jaws, and the sharp, pointed teeth with which each is armed. Hence elicit that the crocodile is a flesh-eater. It feeds on fish, on the animals which come to the river to drink, and on any living thing that it can catch—sometimes on men.

Throat, nostrils, and mode of catching prey.—The crocodile, lurking under the bank, sweeps into the water with a blow from its strong tail any creature that may come to the river-side. The crocodile then seizes the creature with its jaws and holds it under water till drowned.

The crocodile itself would be drowned if water got into its lungs, but this is prevented

(1) By the position of the nostrils. They are placed at the end of the snout, which is very long, so that they are above water while the prey is under.

(2) There is a kind of leathery flap in the throat, and this acts as a trap-door, keeping out the water which must enter the mouth.

Eggs.—The crocodile lays eggs which, notwithstanding its size, are not bigger than a goose's. It buries them in the sand [*'To be hatched by ——?'*], but stays near to watch them. The natives, knowing this, hide near and wait till it is asleep, when they kill it.

Fortunately, several creatures are fond of the crocodile's eggs.

One, sometimes called 'Pharaoh's rat' [the ichneumon], eats a very large number of them.

The young crocodiles are only a few inches long. Compare to lizard. As soon as they are hatched they run to the water, where they will snap and bite as fiercely as if they were full-grown.

SNAKES

How snakes move.—'*How many legs have snakes?*' '*How do they move, then?*' Let the children feel their own spines. The spine or 'backbone' consists of a number of

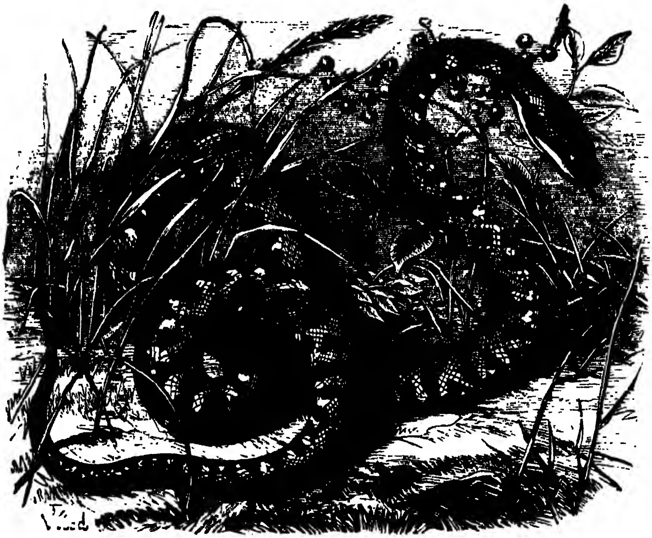


FIG. 59.

separate bones joined together. These bones run through the whole length of the snake, and are joined together in the same way as the arm is joined to the shoulder. [A ball-and-socket joint]. Show that this joint allows great freedom of motion.

Let the children feel their ribs, and make them note that all

the ribs are joined behind to the spine, and that some are joined in front to the breastbone.

Snakes have no breastbone. Most of the bones of the spine have each a pair of ribs all free in front. These ribs can be moved backwards and forwards at will.

The skin of the snake is covered with scales. Some of those on the upper part of the body are fixed all round, but most of them are fixed only by the front edge, so that the points directed backwards are free. On the lower surface, too, the scales are larger and often arranged in bands.

By means of the free ribs these scales are pushed forward and drawn back. Their free edges hitching on any roughness in the ground or a tree-trunk, draw the body forward with a gliding movement. Thus snakes could not move on a perfectly smooth surface. '*Why?*'

How snakes swallow.—Each jaw has a large number of small, very sharp teeth, all pointing backward. These teeth are used not for biting but for holding. The jaws are pushed forward and then drawn back, and the prey is thus brought further and further in.

Snakes can swallow creatures much thicker than themselves, because

(1) The bones of the jaw are not joined together. They are simply held in their place by the skin, which is as elastic as indiarubber.

(2) The ribs do not meet in front, and the skin of the body is also elastic.

Thus the middle part of a snake's body may often be seen bulging out, showing the shape of some animal that has been swallowed.

Poisonous snakes.—Snakes that are not poisonous live on creatures having no means of defence. Thus the British grass snake lives on frogs, which, when once caught, can be easily swallowed; but the British viper lives on mice, which would bite, and on birds, which would flap their wings. This snake therefore poisons its prey before swallowing.

Poisonous snakes have no sting, but in the front of the upper jaw they have two long, sharp, curved teeth called the

poison fangs. When the mouth is closed these lie against the upper jaw, but when the mouth is open they project, with the point backward. They are hollow, and at their root is a kind

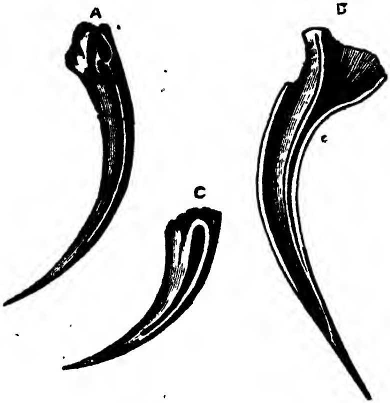


FIG. 60.—Poison fangs, showing internal hollows. A, superficial view, B, longitudinal section; C, tooth of hydrophis, with open poison groove.

of large bag filled with poison. In the act of striking, the muscles which close the jaws squeeze this bag and drive the poison through the fang into the wound.

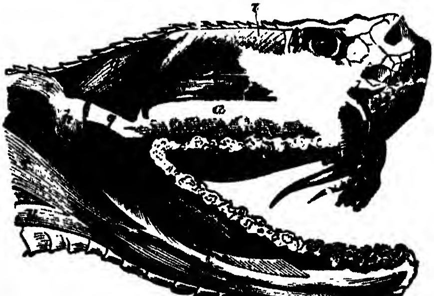


FIG 61.—Poison apparatus of Rattlesnake. *a*, poison bag and duct; *e*, *i*, *g*, *t*, *u*, muscles of jaw.

Tongue.—A snake's tongue is small and forked. It is used for feeling, not for stinging.

British snakes.—Of all British snakes the viper is the only one which is poisonous. It is generally of a dark olive brown, though specimens may be seen yellow, red, or nearly black. Whatever its colour, the viper may always be known by the 'markings' on its skin. On the top of the head there is a black V [Remember 'V' stands for *viper*], and down the back there is a row of square black spots arranged zig-zag, almost like the squares on a chess-board.

THE BUTTERFLY

[The school museum probably contains specimens of the chrysalis and of various butterflies. If the lesson is given in the summer there will be no difficulty in illustrating it with butterflies and caterpillars. A large picture is also necessary.]

Food.—Butterflies live on the juices of flowers. Hence elicit that

(1) We see butterflies only in warm weather, when flowers are plentiful.

(2) They need no teeth.

(3) They must have suckers.

(4) They must be able to fly.

Sucker.—The butterfly has no mouth or teeth. '*Why?*' Instead of them it has a long trunk or sucker, which, when not in use, is coiled like a watch-spring under the head. This is divided into two parts by a slit down the middle, each part being grooved. They have tiny hairs all the way down, and the two parts are made into one tube by the interlacing of these hairs. Compare to the union which can be effected between two blacking-brushes by striking them smartly together. These hairs keep back any particles which might be mixed with the juice. After a meal the two parts of the sucker are separated, and the two front legs are employed in cleaning them.

Feelers.—In front of the head is a pair of feelers. [The technical name, *palpi*, need not be given. The same re-

mark applies to the other technical terms that occur.] They can be pushed out or drawn in at pleasure. Compare to snails.

Horns (antennæ).—These stand out from the front of the head, and each ends in a small knob. We can tell a butterfly from a moth by the fact that the antennæ of the moth have no knobs. The use of the horns is not certainly known, but when they are cut off the insect cannot fly.

Eyes.—On each side of the head a large eye stands out like a bead. Show a piece of glass cut into facets. The eye is made up of thousands of little facets, each of which can see. '*Who has tried to catch a butterfly by creeping up behind it?*' '*What did it do?*' Hence elicit that it can see in all directions.

On the top of the head, half buried in down and scales, is another pair of eyes, much smaller than the first.

Legs.—Like all other insects the butterfly has six legs. These are fastened to the chest. The front pair is small; use already given. The other pairs are seldom used for walking, but for resting the body while the juice is sucked from flowers.

Wings.—Four. Show the beautiful colours. '*What have you noticed on your fingers after you have been holding a butterfly?*' This dust consists of little scales. They lie one over the other like the tiles on a roof, and they are of many different colours. When they are rubbed away there are little black spots showing where they have been.

FIG. 62. Caterpillar.

Eggs.—The butterfly lays eggs and then dies. The eggs are laid upon a leaf of the plant upon which the caterpillar that comes out of them feeds. They are fastened to the leaf by a kind of fine glue.

Caterpillar (larva).—When the sun is warm enough it hatches the egg, out of which comes a little caterpillar or grub. This little creature at once begins to eat, first its own shell, and then the leaves around. In twenty-four hours it eats more than twice its own weight. Eating so much it grows very fast, and its skin gets too small. The skin cracks, the caterpillar comes out with another, and once more begins to eat. This happens four or five times.

Pupa or chrysalis—Then the caterpillar finds that it cannot eat any more. It fastens itself up to a leaf, or a twig, or a wall, by means of threads which it spins. Compare to a spider's web. The skin shrivels, and a very strange-looking creature comes out. Show chrysalis or picture of one. It now seems quite dead, and remains in this state till the warm weather. Then the shell bursts, and out comes the perfect butterfly.

THE BEE

[Illustrate with large picture, a few dead bees, honeycomb, wax, and honey.]

Wild and hive bees.—In different parts of the world there are wild bees, which live in hollow trees or holes in the rock, but the honey and wax are so useful that in civilised countries bees are kept in hives.

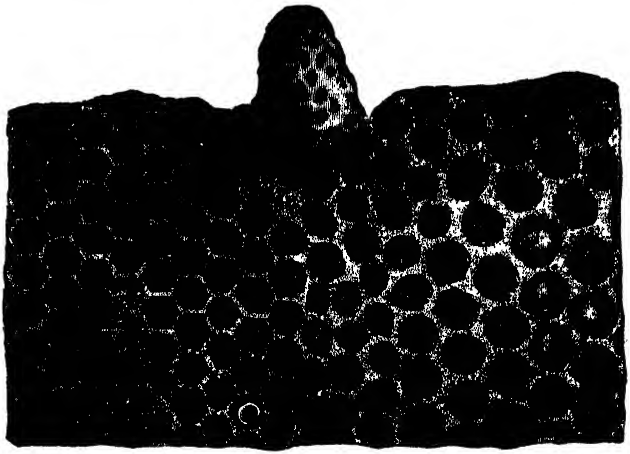


FIG. 63.

Cells.—The first thing bees do after being placed in a hive is to make 'honeycomb.' One bee hangs from the roof and

others hang to her. From six little pockets in their bodies they squeeze out wax, which they knead with their teeth and form into six-sided cells. Show honeycomb. Also draw, and demonstrate that with hexagonal cells no space is wasted.

FIG. 64.—Drone. FIG. 65.—Worker. FIG. 66.—Queen.

Kinds.—In each hive there are three kinds of bees. First there is the *queen*—one to each hive. She has a longer body and shorter wings than the others. She does not leave the hive. She lives four years, and goes on laying eggs the whole time, putting one in each cell.

The *drone* is the male bee. It has no sting and does not work. Hence a lazy person is called a drone. There is only one drone to about a thousand workers. In the autumn all the drones are killed.

Most of the bees in a hive are *workers*. They build the cells, gather honey, and tend the young.

Structure.—Compare with the structure of the butterfly. The bee may be divided into the same three parts—head, chest, and abdomen. To the chest are similarly joined six legs and four wings.

Tongue.—Long, edged with hairs like a brush. With it the worker licks the juice out of flowers. This juice is stored up in a little bag till the worker returns to the hive, when it is squeezed out into a cell, the mouth of which is then stopped with wax.

Legs.—On each hind leg is a little basket made of stiff hairs. In this is stored the yellow or white dust found on flowers (the pollen). This is mixed with honey to feed the young bees.

Sting.—The sting is in the hind part of the body, in which

also is a poison bag. It is the poison that causes the part stung to swell and be painful. There are only three British insects with real stings—the bee, the wasp, and the hornet.

The young.—As soon as a number of cells are made the queen begins to lay eggs in them. In a few days these change into little white grubs. They have no legs and cannot feed themselves, so a number of workers stay in the hive to act as nurses. After about a week the grubs begin to spin a silken covering for themselves, and when they are about three weeks old they come out perfect bees.

Swarming.—The hive then becomes too full, and the queen goes off with a great number of the bees to find a new home. She settles on the branch of a tree, all the rest hanging around her, till the owner comes with a new hive and shakes them into it. Before the swarming a young queen has been hatched, and she becomes the head of the old hive.

THE HOUSE-FLY

Recapitulate the structure of the butterfly and the bee and show that the structure of the fly is in many respects similar—head, chest, abdomen; six legs; four wings (with modification); changes.

Mouth.—The mouth contains the trunk, which is tongue, lips, and teeth all in one.

Eyes.—Elicit, as in the case of the butterfly, that a fly can see in all directions. The structure of the eyes is the same.

Feelers.—Two. Supposed to be for hearing and smelling as well as for feeling.

Legs.—Six, each with three joints. The feet have claws, hairs, and soft pads. Illustrate the action of a boy's sucker. It is believed that the pads on the fly's feet act in the same way, and that this is why flies can walk up the window and on the ceiling.

Wings.—'*How many wings has the butterfly?*' '*And the bee?*' All true insects have four wings. Show a fly, and let

the children try to find the four. They will probably be able to find only two; but if they look very carefully behind those they will see two very small ones. These are called 'balancers' or 'poisers,' and if even one of them is injured the insect cannot fly, but can only flutter about on the ground.

Development.—The fly lays eggs. The warmth of the air hatches these, and out of them come little grubs. Unlike the grub of the butterfly, these have no legs; but they have a number of sharp bristles set round each of the rings of the body, and by means of these the little creatures can wriggle backwards and forwards. Refer to bluebottle grub, which the children may have seen in meat.

The grubs eat greedily, and in a few days grow to their full size.

Then the skin hardens into a case, and the grub seems dead. After a time the covering (of the 'pupa') bursts, and a fly comes out.

THE ANT

An 'ant-hill.'—Find out the children who have seen an 'ant-hill,' and ask them what they noticed. Bring out by questions that ants, like bees, live together in large numbers; that their home is not in a hive, but underground; and that when seen underground they have no wings, though they are true insects.

Kinds.—'*How many kinds of bees are there?*' There are the same three kinds of ants: the males, the females (or queens), and the workers; but a hive has only one female, while an ant-hill may have several.

Wings.—All the ants the children saw in the ant-hill were wingless, and the workers are always wingless; but in the autumn males and females have four wings, and leave the nest in thousands. They choose their mates in the air, after which the males soon die. Such of the queens as escape the birds snap off their wings and start new homes.

Development.—The females lay eggs, out of which come little grubs like those of the bee. The largest become females

and the smallest workers. They are all quite helpless, and have to be tended by some of the workers. When the grub is about to become an ant it spins a cocoon like that of the silk-worm, only much smaller. Show if possible. Doubtless the children who saw the inside of a nest noticed some of the ants running about with these cocoons, and may have been told (erroneously) that they were eggs. These cocoons must not be too hot or too cold. When the day is warm they are taken to the lower galleries of the nest ['*Why?*'], and when the day is cold they are taken up to get what heat they can from the sun.

Food.—It is a mistake to suppose that ants store up corn for the winter. They sleep through the cold months just as bees do, and they could not eat corn if they had it.

Habits.—Give a brief account of some of the most interesting habits of ants—their wars, their 'slaves,' their 'milking' of aphides, &c.[1]

THE SPIDER

[Place side by side large pictures of the spider and of some true insect, such as the bee. It would be well also to have specimens of the two creatures.]

The spider is not an insect.—By comparing the specimens and the pictures bring out that the spider differs from the bee (or other insect) in the following ways:—

(1) The bee has six legs, the spider eight.

(2) The body of the bee is divided into three parts—head, chest, and abdomen—while the head and chest of the spider make one part.

(3) The bee has four wings, the spider none.

There are two other very important differences, which the children cannot be made to see:—

(1) The bee breathes through a vast number of little air-

[1] The white ant, of whose destructive powers such extraordinary tales are told, is not an ant at all. It belongs to the same order as the dragon-fly (the *Neuroptera*), whereas the ant belongs to the *Hymenoptera*.

tubes which run to every part of its body, and the spider breathes by means of lungs.

(2). The bee comes out of an egg and passes through a number of changes, but the spider is born a spider.

Fig. 67.

For these and other reasons we say that the spider is not an insect.

Claws.—Spiders live on insects. Some kinds hunt their prey, and others catch it in webs. All kinds kill it with poison. The upper jaw has one or more pairs of claws with a small hole in each. At the base of the jaw is a little bag containing poison. When the spider catches an insect the pressure of the jaws forces some of the poison into the wound. Compare to the action of the fangs and poison-bag of a snake. The poison of the spider is very powerful, and in hot countries there are spiders which can kill a bird with a single bite, and can cause much pain even to a man.

Web.—There are many kinds of webs—the house spider, for instance, has a different one from the garden spider. Every web is made of threads coming from the spider's body. Near

the tail are from four to eight small lumps called 'spinnerets,' each full of little holes Inside the body is a large bag filled with a thick, clear fluid. When the spider wishes to spin a web it squeezes a drop of this fluid through the spinnerets and places it against the object to which it wants to fasten its line. It then removes its body, thus drawing out the fluid into a thread which is at once hardened by the air. The line is really made up of a large number of threads, like our ropes. Describe the construction of a web—say, the garden spider's. The threads are very elastic, and covered with a sticky substance.

When a fly comes against the web it is caught there by this sticky substance. The spider rushes from the centre of the web or from its hiding-place, grasps the fly, turns it rapidly round and round with its fore feet, covering it completely with a broad silken band which makes it quite unable to move. Then the spider kills it with a bite, and either eats it at once or leaves it till needed.

If a wasp or other large insect is caught, the spider does not venture near till the struggles of the captive have caused it to be securely fixed in the web.

THE SNAIL

Shells.—Snails live in shells. Show. Procure empty shells, and break one or two to show the internal structure. Question on the use of the shell to the snail. If the shell is entirely removed the snail dies.

The 'foot.'—The flat under part which can be seen when a snail is out of its shell is the 'foot,' by means of which the creature creeps. (See Fig. 68, A.)

The head.—Joined to the 'foot' below, but partly separate above, is the head.

Tentacles and eyes.—There are two pairs of feelers. Show the action in a living snail. The hinder and larger pair has eyes at the end. Show the advantage of having eyes at the end of feelers which can point in all directions. Let the

children see from living specimen how the snail protects its eyes by 'retracting' and 'inverting' them.

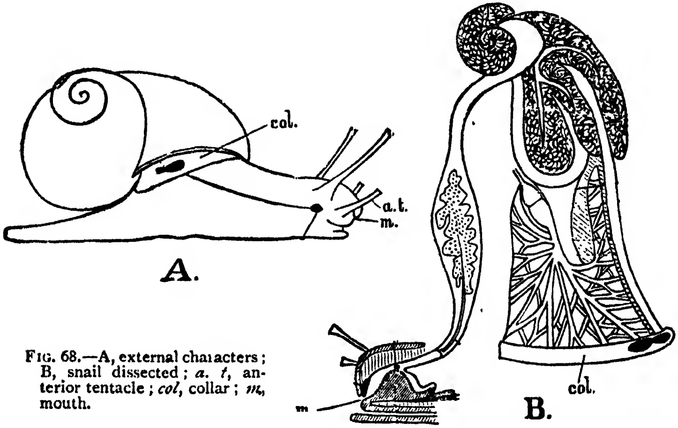


FIG. 68.—A, external characters; B, snail dissected; *a. t*, anterior tentacle; *col*, collar; *m*, mouth.

The Tongue.—The tongue of the snail, like that of the other creatures of its class, consists of a long band covered with roughnesses often called teeth. This band acts as a rasp or file.

Breathing.—Just within the lip of the shell is a thickened ridge called the 'collar.' (Fig. 68 A, *col.*) In this is an opening leading to the organ by which the creature breathes.

Food.—Ask about the action of snails in a garden, and hence elicit that they live on vegetables. They will, however, eat their own dead.

Hibernation.—There is a dearth of food in winter, and hence snails pass the cold months in a state of sleep. They creep into crevices, or under stones, or under heaps of leaves, which they stick together with their own slime. They draw themselves into their shells and cover the mouth with a kind of door. The snail arranges its 'foot' so as to fill the opening, pours out slime, mixes it with earth, and then withdraws its

'foot.' The cover soon hardens, and the snail sometimes makes two or three more further in of slime alone.

Snails delight in warm, moist weather. They are always active at night when the ground is covered with dew, and in the day-time after rain.

In hot countries, where there is no winter, they sleep during the dry season.

Eggs.—Snails lay eggs about the size of a pea. These eggs are covered by a skin, and may often be found in gardens just under the surface of the soil.

Edible snails.—The whelk and the periwinkle, which are only sea-snails, are eaten, and there is no reason why the land-snail should not be eaten also, as in fact it is in France and Italy. The ancient Romans reckoned snails a great dainty, and fattened them for the table. The feeding made them grow to a great size, and an old writer (Pliny) says that three snails, two lettuces, two eggs, a barley cake, sweet wine, and snow made a good supper for himself and his friend.

THE EARTH-WORM

Lives.—The worm is adapted for living underground

(1) By its shape. Show a worm, and make the children note that the head is pointed and that there are no parts sticking out from the body.

(2) It has no legs. The mole, which also lives underground, has very short legs.

(3) It is covered with slime. Let the children feel it. This keeps the earth from sticking to the body.

Rings and motion.—The body of the worm is made up of a large number of rings. Refer to the way in which a snake moves. Though a worm has neither ribs nor scales it moves in much the same way. Around most of the rings are set eight little bristles. These can be felt as a living worm is pulled backwards through the fingers, and they can readily be seen with a lens. The bristles are curved and pointed. The

worm moves by extending its body, seizing any roughness with its bristles, and then contracting.

Food.—The worm lives chiefly on vegetable matter, especially decaying leaves. It swallows much earth, but this is the only way it has of carrying to the surface the soil displaced in making its hole.

Mouth.—The mouth is an opening under the first ring. The worm drags its food underground, and before swallowing moistens it with a kind of slime, which helps to digest it.

Senses.—Worms come up chiefly at night, and may then often be found half-way out of their holes. If a light be suddenly shown they withdraw at once, which proves that though they have no eyes they are sensitive to light. They are also very sensitive to any motion, even the breath of a spectator being enough to make them retreat. They have no ears or nose ; but they must have some sense of smell, as they can find out favourite food and distinguish red from green cabbage. They show fondness for carrot, celery, onion, and horse-radish.

Uses.—Ask if the children have seen on lawns or in meadows the curiously twisted little heaps of earth known as 'worm-casts.' These are the earth dug out by the worm when burrowing, and, though gardeners dislike to see them, they are useful as manure.

The passages made by the worm are also useful, as they let in rain and air to the roots of plants.

The worm also does good by turning leaves and other vegetable matter into manure, which it places beneath the earth where it is wanted.

C: Lessons on Flowers

THE WALLFLOWER

[Provide enough flowers to let each child have at least two perfect specimens. Let each child also have a slate or a piece of paper divided by three horizontal lines into four equal parts.]

Calyx.—'*What is the name of this flower?*' '*What is the name of this part?*' [The stem or stalk.] Notice that at the top of the stalk and under the blossom there are some little leaves. These seem to form a little cup for the blossom, and are called the *calyx*.

Each of the little leaves forming the calyx is called a *sepal.* '*How many sepals has the wallflower?*' [Four.] '*What is the colour of them?*' In most flowers the sepals are green, but in the wallflower they are often reddish. '*Are the sepals joined to one another?*' Let each child pull off the sepals, lay them on the first division of the slate (or paper), and write underneath them, 'Four sepals make the calyx.'

Look at the perfect flower and see how the sepals are placed on the stalk. [One pair above the other.] '*Are the sepals of the same size?*'

Corolla.—We now come to the blossom. Those who study plants call this the *corolla* (a Latin word meaning a small crown).

Each leaf in the corolla is called a *petal* (a Greek word meaning a leaf). '*How many petals has the wallflower?*' [Four.] '*Are they joined to one another?*' Let children pull them off, lay them on the second division of the slate (or paper), and write underneath, 'Four petals make the corolla.'

Look at the perfect flower and see how the petals are arranged. [They form a cross.] Notice the shape of the petals. They look like leaves, each with a long white stalk or claw and a broad, coloured blade.

Stamens.—You now notice a circle of little white threads with powdery heads. Each of these is called a *stamen* (the Latin word for thread). Let children pull them off carefully and lay them on the third division of the slate (or paper). '*Were the stamens joined to one another?*' '*How many are there?*' [Six.] Write, 'Six stamens.' Notice the length of them. [Four long and two short.]

Pistil.—'*What is now left?*' This thickish green body standing on the stalk is called the *pistil* because in many flowers it is shaped like a pestle. Let the children pull off the pistil, lay it on the fourth division of the slate (or paper), and write underneath, 'Pistil.'

Blackboard summary.

WALLFLOWER.

Calyx = four sepals.
(1) Nearly of the same colour as the blossom.
(2) Quite separate.
(3) All equal.
(4) Two above, two below.

Corolla = four petals.
(1) Quite separate.
(2) All equal.
(3) Shaped like a leaf with a long stalk.

Stamens.
(1) Six (four long, two short).
(2) Quite separate

Pistil.

[This lesson should be thoroughly revised till the children are quite familiar with both the names and the things introduced.]

THE PRIMROSE

[Let each child have long-styled and short-styled primroses, and a slate or paper divided by a horizontal line into two equal parts Before beginning the last part of the lesson give out a wallflower to each child.]

Two kinds.—'*What is the name of this flower?*' '*Show the corolla.*' '*Look at the centre of each.*' '*Place on the upper half of your slates (or papers) the flowers with little yellow points in the centre, and on the lower half the flowers with little green points in the centre.*' '*Pull the corolla gently away from the stalk of each flower in the upper division, and lay down the parts in the division.*' '*Do the same with the flowers in the lower division.*'

Calyx.—'*Colour?*' [Green.] '*Number of points?*' [Five.] '*How many sepals, then?*' '*Are they separate or joined?*' [Joined.] Notice the puffed appearance and the five ridges.

Corolla.—'*Number of petals?*' [Five.] '*Equal?*' '*Shape?*' [Slightly divided at the top.] '*Try to separate one petal from the rest.*' [They are united.] The lower parts form a tube.

Stamens.—'*Take up a corolla from the upper part of the slate (or paper).*' '*Tear it so as to lay open the tube.*' '*What do you see at the upper part of the tube?*' [Little yellow heads.] '*What are these?*' [Stamens.] '*Count them.*' [Five.] '*What do you notice about the length of them?*' [They are very short.]

'*Now tear open a corolla from the lower part of the slate (or paper.*' '*Where are the stamens?*' [In the lower part of the tube.] '*Count them.*' [Five.]

'*Where are the stamens fixed in both kinds of flowers?*' [On the tube of the corolla.]

Pistil.—Cut or tear open a calyx from the upper division. '*What do you see on the stalk?*' [The pistil.] Point out resemblance in shape to a pestle, mentioned in the last lesson.

Now cut or tear open a calyx from the lower division. Show the pistil. '*What is the difference between the pistils of*

the two flowers cut open?' [The pistil in the upper division is short, and in the lower division long.]

'*Into how many parts may each pistil be divided?*' [Three.]

(1) The little lump at the top of the flower stalk is called the *ovary*.

(2) The thread running up from the ovary is called the *style*.

(3) The little lump at the top of the style is called the *stigma*.

Primroses are of two kinds—

(1) Short-styled (stamens above stigma).

(2) Long-styled (stamens below stigma).

Comparison with wallflower.—Work out the comparison, which will give the following blackboard summary :—

	Wallflower	*Primrose*
Calyx . .	Reddish	Green
	Four sepals	Five
	Separate	United
Corolla .	Four petals	Five
	Separate	United
Stamens .	Six	Five
	On stalk	On petals
	Long threads	Short threads
Pistil . .	The same in every flower	Some short-styled, some long-styled

THE BUTTERCUP

[Provide flowers as in the preceding lessons. Also, as in the lesson on the wallflower, let children have slates or paper divided horizontally into four equal parts. The number of sepals, &c. varies very much in the different and even in the same species.]

Calyx.—'*What is the name of this flower?*' '*Show the calyx.*' '*How many sepals?*' [Five.] '*Colour?*' [Yellowish-green.] [Under the name *Buttercup* are included at least three different flowers, all common. It matters little which kind is

taken, but note that the sepals are spreading or sharply curved back according to the kind of flower taken.] Make the children observe that the sepals are equal and quite separate ('free'). Let children pluck off sepals and place them on the highest division of their slates (or papers), writing, 'Calyx = five sepals.'

Corolla.—'*Colour?*' '*How many petals?*' [Five.] Have the petals plucked off and placed on second division of slates (or papers). 'Five petals = corolla.' Make children observe that the petals are equal and quite separate ('free').

Petal of wallflower was like a leaf with a long stalk or claw. Petal of buttercup is almost, but not quite, without stalk.

Stamens.—Have them plucked off and placed on the third division of slates (or papers). Ask children to count them. Answers will probably vary; no answer will be under twenty. In such cases the number of stamens is said to be 'indefinite.'

Stamen can be easily divided into two parts—

(1) A thread-like stalk, called a *filament* (from a Latin word meaning a thin thread).

(2) A yellow head, called the *anther.*

From the anthers comes a yellow dust, called *pollen.*

Pistil.—Each of the little green points now left is the stigma of one part of the pistil of the buttercup. Each part is called a *carpel.*

Place them on the fourth division of the slate (or paper). Count them. (Indefinite.) Write, 'Carpels (indefinite)=pistil.'

'*Into how many parts did we divide the pistil of the primrose?*' [Three—stigma, style, ovary.] The ovary and style may be seen in each carpel of the buttercup. Inside the ovary is a little body which becomes the seed.

Blackboard summary.—Recapitulate the lessons on the Wallflower and the Primrose so as to bring out the table given at the end of the second. Add another column with details of the buttercup.

THE DEAD-NETTLE[1]

Nettles.—There are two kinds of nettles growing wild in all parts of the country—one, which stings when touched, and the other, which does not sting, and is called the dead-nettle. The latter has white or purple flowers. [The dead-nettle with white or that with purple flowers will do for the purposes of this lesson, though the white is preferable on account of the larger size of its flowers.]

Calyx.—Green ; easily detached ; five sepals, united ; not all of the same size.

Corolla.—Note the shape. The petals of the preceding flowers were of the same size ; these are unequal. The corolla is supposed to look something like a mouth with two lips [*bi-labiate*]. The upper one, which bends over, has two divisions, the lower one three. There are therefore five petals (united).

Stamens.—The little hollow box which stands at the summit of a stamen is the *anther*, and contains the *pollen*. The anthers of the dead-nettle are black. By counting them it will be seen that there are four stamens. The two outer and lower ones are longer than the other two. The stamens, as in the primrose, spring from the coralla tube, as will be seen if it is cut open.

Pistil.—Long, white, forked at the top.

Insects.—It is necessary that the pollen of one flower should be carried to another. This is a task which insects often unconsciously perform in their search after honey. The peculiar shape of the dead-nettle facilitates the deposit in one flower of the pollen caught on the body during a visit to another. The stiff hairs placed inside the corolla tube are supposed to be for the purpose of keeping small insects away from the honey.

[1] In this and the following lessons on flowers the same method should be followed as in the preceding. Only the facts are given here.

THE TULIP

[Illustrate with 'single,' not 'double' flowers.]

Calyx and Corolla.—The flower seems to have no calyx, and the corolla to be made up of six equal petals not united. These are arranged in two circles of three, the leaves of the outer circle being placed opposite the openings between those of the inner circle. When the calyx and the corolla are thus alike they are called the *perianth.* (Gr. πεpί—*peri*—'around,' and ἄνθος—*anthos*—'a flower.')

Stamens.—Six, conspicuous, springing from the end of the stalk below the pistil.

Pistil.—Also conspicuous; has three lobes or divisions.

Leaves.—Parallel venation. (See p. 122.)

THE DAFFODIL

[Cultivated daffodils, like many other cultivated flowers, are generally 'double.' For the purposes of this lesson procure wild specimens, which are sure to be 'single.']

Name.—The connection between the word *daffodil* and the word *asphodel* may be passed over; but as the children have probably heard the flower called the March lily and the Lent lily the teacher should explain that it receives these names because it has some likeness to the lily and blooms in March and April (Lent).

Perianth.—As in the tulip, there is no separation of the flower leaves into calyx and corolla, all being of the same colour and nearly on the same level. Outside *whorl* (or circle), three; inside whorl, three, of the same size, and all united.

Corona.—In the middle part of the flower is a large deep tube to which the leaves of the perianth adhere. This is called the *corona* (Lat. 'a crown') from its shape and position. Impress upon the children that it is not the corolla.

Stamens.—Three above and three below; all on the tube of the perianth.

Pistil.—Style long; stigma triangular; ovary three cells (as may be seen if a transverse section is made); therefore three carpels.

Leaves.—Parallel venation.

THE GARDEN PEA

[The meadow pea and the sweet pea will serve equally well for illustration.]

Calyx.—Green. The flower therefore differs from the tulip and the daffodil in having no perianth. The sepals are united, but the teeth show that they are five in number.

Corolla.—Butterfly-shaped, like that of the bean. The petals are unequal. The largest (at the back) is called the standard. The two situated below it, one on each side, are the wings. It might, at first sight, appear that there is but one more, enclosing the stamens; but closer examination will show that there are two, slightly coherent along their lower edges. These two are called the *keel.*

Stamens.—If a section be made through the middle of the flower from below upwards, the stamens will be seen, owing to a slight adhesion contracted with the bottom of the calyx, to spring from its lower part. There are ten stamens, nine united by their filaments (or stalks) into a bundle, and the upper one distinct.

Pistil.—The pistil is free from the calyx, and consists of a single carpel. Ripened it is the pod, to which the calyx adheres.

Leaves.—Compound, with stipules (large in the garden pea, but much smaller in the meadow and sweet pea). The upper ends of the leaf-stalk are changed into tendrils. The stem is too weak to stand upright of itself, and the tendrils help the plant to find support by climbing. The leaf is in constant motion, going round and round by 'bowing' in all directions, so as to enable the tendril to reach any neighbouring object.

THE DAISY

[The parts of a daisy (even of a 'dog' daisy) are too small to be seen properly without a magnifying glass, and in most cases providing each pupil with a glass is out of the question. The teacher should therefore have a good one, and draw clearly on the blackboard what he sees.]

Rays and disc.—The white leaves outside are called *rays*, and the yellow ones inside form the *disc*.

Florets.—If a few of the white leaves and a few of the little yellow bodies be examined under the glass it will be seen that they are hollow, and that each one is, in fact, a little flower. The daisy, therefore, is not a simple flower like those hitherto taken, but it is made up of many little flowers, each called a *floret*.

Compound.—Flowers which (like the daisy, the dandelion, the marigold, the thistle, &c.) are made up of florets are said to be *compound* or *composite*.

Disc florets.—When one of the disc florets is examined under the glass, the corolla is seen to have five points—in other words, it has five petals which are united.

The calyx is difficult to distinguish, but it is present.

There are five stamens inserted on the corolla and united by the anthers.

Ray florets.—The ray florets have strap-shaped corollas made up of five petals united. The calyx here also is difficult to distinguish. There are no stamens.

Involucre.—Around the base of the ray florets is a circle of green leaves looking like a calyx, but a compound flower has no calyx. This whorl is called an *involucre*, and each leaf is called a *bract*.

Common receptacle.—With a sharp knife make a cut downwards through the middle of a daisy. The white and yellow florets will be seen to stand (without stalks) upon a rounded enlargement of the flower stalk. In simple flowers this is called the *receptacle*, and in compound flowers the *common receptacle*.

THE DANDELION

Dandelion and daisy.—Like the daisy, the dandelion is a compound (or composite) flower; but there is one obvious difference—in the dandelion the florets are all yellow, whereas in the daisy some are white and some yellow.

Pappus.—Take one of the outside florets. In the lower part will be seen a little oval body, the *ovary*. On the top is a ring of hairs (Fig. 144). This takes the place of the calyx, and afterwards forms the down which carries the ripe seed through the air.

Corolla.—Rises from the top of the ovary from within the hairs. It begins as a tube, but spreads out as a strap ending in five points. Hence we say that it has five petals, united.

Stamens.—Five. The filaments spring separately from the tube of the corolla, but, as in the case of the daisy, the anthers unite.

Down.—When the seeds of the dandelion are ripe the bracts turn backward. Each corolla falls away, and the narrow part between the ovary and the pappus grows straight up, bearing on it the pappus, which gradually spreads out horizontally as down. When the seed is ripe, it is with the least breeze carried into the air by the down.

COMPARISON

[(1) The flowers examined in the present course should now be compared, not by recollection, but by fresh observation. As many of them as are in bloom should be produced; for the rest there should be drawings and pressed specimens.

(2) The chief facts about a flower are commonly shown by means of Professor Henslow's 'Schedule.' The form of the schedule is preserved in the following tables, but the use of technical terms has been avoided. In the column headed 'Cohesion' the facts with regard to the union or freedom of the parts of any whorl are stated, and in the column headed 'Adhesion' the facts with regard to the union of whorls.]

FLOWER	ORGAN	NO.	COHESION	ADHESION
WALLFLOWER	Calyx			
	Sepals .	4	Free (equal).	Not attached to pistil.
	Corolla			
	Petals .	4	Free.	
	Stamens .	6	Free	Below the pistil.
	Pistil			
	Carpels .	2	United . . .	Not attached to calyx.
PRIMROSE . .	Calyx			
	Sepals .	5	Coherent.	Not attached to pistil.
	Corolla			
	Petals .	5	Coherent.	
	Stamens .	5	Free	Spring from corolla tube.
	Pistil			
	Carpels .	5	United . . .	Not attached to calyx.
BUTTERCUP .	Calyx			
	Sepals .	5	Free	Not attached to pistil.
	Corolla			
	Petals .	5	Free (equal).	
	Stamens .	Indefinite	Free	Below the pistil.
	Pistil			
	Carpels .	Indefinite	Separate . .	Not attached to calyx.
DEAD-NETTLE	Calyx			
	Sepals .	5	Coherent . .	Not attached to pistil.
	Corolla			
	Petals .	5	Coherent (unequal)	Below the pistil.
	Stamens .	4	Two long, two short	From the petals.
	Pistil			
	Carpels .	2	United . . .	Not attached to calyx.
TULIP . . .	Perianth .			
	Leaves .	6	Applied to perianth, consisting of free leaves	Not attached to pistil.
	Stamens .	6	Free	Below the pistil.
	Pistil			
	Carpels .	3	United . . .	Not attached to calyx.

FLOWER	ORGAN	NO.	COHESION	ADHESION
DAFFODIL . .	Perianth *Leaves* .	6	Applied to perianth, consisting of united leaves	Stands in place of calyx.
	Stamens .	6	Free	Attached around ovary.
	Pistil *Carpels* .	3	United . . .	Adherent to ovary.
PEA	Calyx *Sepals* .	5	United . . .	Not united to pistil.
	Corolla *Petals* .	5	Free	Attached around ovary.
	Stamens .	10	Arranged in two sets	Attached around ovary.
	Pistil *Carpels* .	1	One carpel . .	Not united to calyx.
DAISY, DANDELION	Calyx *Sepals* .	5	United . . .	Not attached to pistil.
	Corolla *Petals* .	5	United . . .	Attached above pistil.
	Stamens .	5	United by anthers.	Attached to petals.
	Pistil *Carpels* .	2	United . . .	Not attached to calyx.

FOURTH YEAR

A: Lessons on Elementary Physics

SOLIDS, LIQUIDS, AND GASES

Solids and liquids.—Place on a table in front of the class a number of the solids and liquids most readily available. Get the children to divide the solids from the liquids, and to name other solids and liquids.

Shape.—Hold up one of the vessels containing a liquid. '*What is the shape of this liquid?*' Pour it into a vessel of a different shape. '*What is the shape of this liquid now?*' Hence elicit the statement that liquids take the shape of the vessels in which they are placed.

Place one of the solids in vessels of different shapes. Make the children notice that it retains its shape.

Support.—Pour a little water on a frameless slate. The water spreads over the slate and finally falls over the sides.

Now place one of the solids on the slate. No change occurs. Hence elicit the statement that a solid can retain its shape without being supported at the sides, but that a liquid cannot.

Cohesion.—Ask the children to push their fingers first through the solids, then through the liquids. '*What is the difference?*' The particles that go to make up a solid stick so close together that it is hard to separate them; but the particles of a liquid can be easily separated. The force which holds the particles together is called *cohesion*. Elicit the statement that cohesion is strong in solids and weak in liquids.

Gas.—Turn on the tap without lighting the gas. In a very short time the furthest children will be able to smell the gas.

This shows that the gas has spread throughout the room. All gases spread in the same way. They have no cohesion.

Recapitulation.—Compare the properties of solids, liquids, and gases.

A. (1) A solid retains its size and its shape.
(2) A liquid retains its size, but will change its shape.
(3) A gas will change both size and shape.

B. (1) Cohesion is strong in solids.
(2) It is weak in liquids.
(3) There is no cohesion in gases.

Change of state.—If possible, show a piece of ice, and elicit that it is water in a solid form. Warm it, and it takes a liquid form. Warm still more, and it becomes a gas (steam).

Few substances are commonly found in the three states, but many solids are easily changed into liquids ['*Name some.*'], and liquids into gases ['*Name some.*'].

EFFECTS OF HEAT

[Two lessons.]

Change of state.—Refer to the closing part of last lesson, where it was shown that heat may change a solid into a liquid and a liquid into a gas.

Expansion.—But it must not be supposed that heat has no effect till a change of state has taken place. Solids, liquids, and gases expand when heated. The expansion of liquids and gases may be easily demonstrated, but the smaller expansion of solids is generally shown by means of delicate apparatus.

Illustrations of the expansion of solids.—(1) A metal rod, (A, Fig. 69) is fixed at one end by a screw, B, while the other end presses against the short arm, C, of an index, D, which moves on a scale. Methylated spirit is poured into the trough under the rod and set alight. As the rod is heated it expands, and

moves the index. If rods of different metal be used, the different degrees of expansion will be seen.

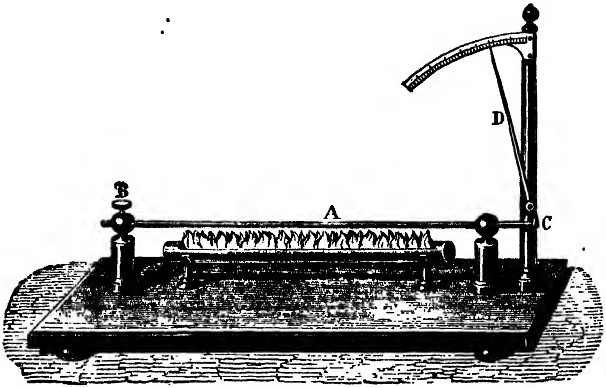


Fig. 69.

(2) The apparatus in fig. 70 is known as 'Gravesande's ring.' It consists of a brass ball, *a*, which, at ordinary temperatures passes freely through the ring, *m*, but which, when heated, will not pass through.

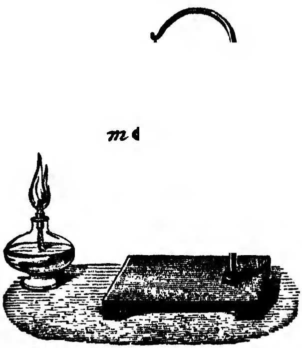


Fig. 70.

(3) Where no special apparatus is available, the expansion of solids, though too small for measurement, may be made visible in its effects. 'A bar or rod of iron about 18 inches long rests upon two blocks of hard wood. One end of the bar is held firmly by a heavy weight. The other end rests upon a sewing-needle. A light straw is fastened at right angles to the needle with sealing-wax, and a divided semicircle is fixed behind the straw. [This may be omitted.] If the rod moves to the right or left, the needle will roll and the pointer will move to the right or left. A very slight movement of the bar will cause a considerable move-

ment of the index. Heat the bar with a spirit-lamp. The temperature rises, and the pointer informs us that the bar is

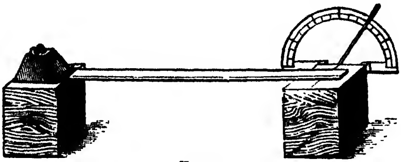


FIG. 71.

expanding. On cooling, the pointer moves to the left, showing that the bar is contracting.'—*Wright*, *Physics*, p. 3.

(4) Let a knitting-needle stand obliquely with its lower end resting against a weight and its upper end against a thin board placed on end. The board should be so placed that the smallest motion of the needle will cause it to fall. Warm the needle, and the expansion of the metal will cause the board to fall.

Practical applications.—(1) The tire of a wheel is, when cold, slightly smaller in circumference than the wheel itself. When heated the tire expands, and is placed on the wheel. It contracts as it cools, and remains firmly fixed.

(2) The pipes of the hot-water apparatus for warming a building expand as the water passes through them. To allow for the expansion the pipes are made to slide one within another. (See Fig. 72.)

FIG. 72.

(3) The summer sun expands the rails of tramways and railways. If no room were allowed for expansion the rails would curve upwards. Spaces (A and B, Fig. 73) are accordingly left at the ends.

(4) A thick glass or bottle often cracks when hot water is

poured into it. The glass being thick, the inside is expanded before the outside.

FIG. 73.

(5) A stopper fixed in the neck of a bottle may often be got out by plunging in hot water, the neck expanding more than the stopper. The same effect is produced by friction on the neck.

Cohesion.—The force of cohesion is diminished when solids are heated. Suspend a weight from the end of a piece of wire; heat the wire, and it breaks.

When a blacksmith wants to cut a piece of iron he first heats it to diminish the cohesion.

Expansion of liquids.—Fill a small flask with water coloured with a little red or blue ink. In the neck insert a cork having a glass tube passing through it. Warm the flask, and the water will rise in the tube.

Thermometer.—Heat is measured by the contraction and expansion of liquids. Have three vessels, the first containing cold, the second tepid, and the third rather hot water. Let one of the children dip his finger into each and arrange the three in order of heat. Now let him first place one hand in the hot and one in the cold water, and then both hands at once in the tepid, which will seem warm to one hand and cold to the other. This shows that we can generally, but not always, tell by our feelings whether a thing is hot or cold, but that we cannot tell how hot or cold. This is done by means of a thermometer. Show one. Show that the liquid expands when heated. There are two fixed points on a thermometer, one showing where the liquid stands in ice ('freezing-point'), and the other where it stands in steam ('boiling-point'). In cheap thermometers this second point is not given.

Mercury is the liquid commonly used. It is open to the disadvantage of freezing in great cold. Coloured alcohol (which is often used) has an opposite disadvantage: it becomes vapour in great heat.

Water.—Water contracts with cold till it is nearly freezing (39·2° Fahr.), and then expands. Elicit that this is why ice floats and pipes burst.

Gases.—Gases also expand when heated. The flask (Fig. 74) contains only air, and the test-tube is at first full of water. The

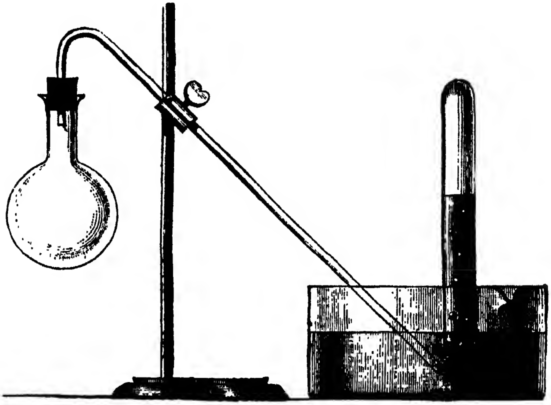


FIG. 74

flask is heated and the air expands, driving the water out of the test-tube. As the air cools it contracts, and water rises again in the tube.

PRESSURE OF LIQUIDS

Downward.—Pour some water into a tumbler. '*What is now pressing on the bottom of the tumbler?*' [The pressure of the atmosphere may be ignored.] '*What is the amount of the pressure?*' [It equals the weight of the water.] Pour in more water. '*What change has taken place in the pressure?*' Point to different depths, and by asking what the pressure at each point is, elicit that it equals the weight of the water at that point, and therefore varies with the depth.

Sideways.—Liquids, besides pressing on the bottom of a

vessel, press on the sides, and the pressure on the sides varies, like the pressure on the bottom, with the depth.

To illustrate this, provide a deep tin with three or four holes at different depths on one side. Close these holes with the fingers and fill the tin with water. Remove the fingers, and a jet of water will spout out of each hole. Make the children observe that the lower the hole the longer the jet, and elicit the reason.

FIG. 75.

If the children have seen a reservoir, canal, or embankment, ask what they have noticed about the sides, and why the sides are made thicker as they go down.

Upward.—Liquids also press upward. It is the upward pressure which makes things float, or causes water to enter a hole in a ship's side. As the upward pressure is equal to the downward, it is greatest at the greatest depth.

Invert a tumbler in some water. Make the children notice that as the tumbler is pressed down some water enters it. '*What was there in the tumbler at first?*' '*What must have happened to the air?*' '*What pressed it closer?*' '*How must the water have been pressing?*'

Take a cylindrical glass open at both ends (such as a lamp glass), with a disc of glass, mica, or card fitting closely to one end Hold the disc under the cylinder with the hand or by means of a piece of string, and push the cylinder into the water. The upward pressure of the water will keep the disc in its place.

FIG. 76

Pour some water into the cylinder till the downward pressure equals the upward, and the disc will fall off.

Transmission of pressure.—Push something along the table

by means of a rod or ruler. '*What made this move?*' Children will probably say that the teacher moved it. He will, however, point out that he did not touch it. Hence elicit that the pressure passed through the rod or ruler. Make the class observe that solids transmit pressure in one direction only. Emphasise this fact.

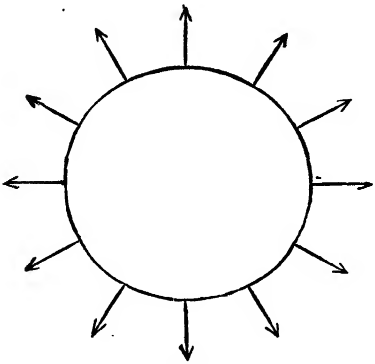


FIG. 77.

Take a hollow indiarubber ball and make in it a number of pin-holes. Fill it with water, and, holding a finger over large hole, press. Water will come out through each of the pin-holes. Make the children note that, though you pressed in only one direction, the pressure is transmitted in all directions.

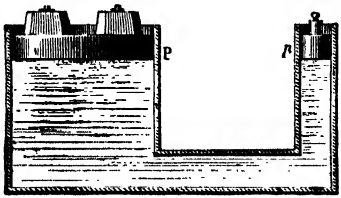


FIG. 78.

Multiplication of pressure. — Liquids not only transmit pressure in all directions, but the pressure transmitted is proportioned to the extent of surface. If the surface at P (Fig. 78) is 20 times that at *p*, 1 lb. at *p* will balance 20 lbs. at P. Give other questions of the same kind. This is the principle of the Bramah or hydraulic press.

PRESSURE OF THE AIR

[Two lessons.]

Amount of Pressure.—The air is supposed to reach forty or fifty miles above the earth. Above every square inch on the face of the earth there is, therefore, a column of air weighing about 15 lbs. Show a piece of paper, card, or board 1 foot square. Hold it horizontally. The air above it weighs nearly a ton. '*Why is the weight not felt?*' Revise what was said about the pressure of liquids, especially that upward pressure equals downward. That is true also of the pressure of the air. Repeat question, '*Why is the weight of the air on the paper not felt?*'

When pressure is felt.—The pressure of the air is felt when exerted on one side only.

If an air-pump is available, perform the following experiment. On one end of a stout glass cylinder, about 5 inches high and open at both ends, a piece of bladder is tied quite air-tight. The other end, ground and well greased, is pressed on the plate of the air-pump. At first the weight of the air above the bladder is counterbalanced by the expansive force of the air inside the cylinder, but when the internal air is pumped out the bladder is depressed, and finally bursts with a loud report.

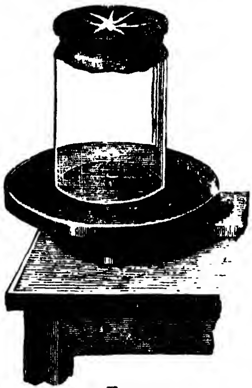


FIG. 79.

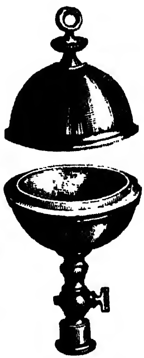


FIG. 80.

Where Magdeburg hemispheres (Fig. 80) are available, pump out the air, and then let two children try to pull them apart. As the air presses on the outside only, they will not succeed.

Many simple experiments can be performed without an air-pump. Care should be taken that the point illustrated is made clear.

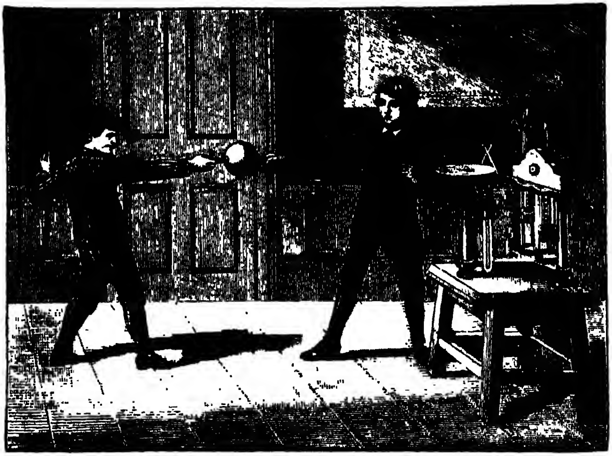


FIG. 81

(1) A sucker. A piece of leather a few inches square. The string should fit very tightly into the hole, and the knot should be very flat. Damp the sucker, and press it well against the floor or any other flat surface.

FIG. 82.

(2) Fill a tumbler with water and cover it with a piece of paper, taking care that the paper touches every part of the rim. Invert the tumbler, keeping the paper in position with the hand. Take away the hand, and the water will remain in the tumbler, being kept in position by the upward pressure of the air. The object of the paper is to preserve a flat surface of water. Without it the water would divide and allow the air to enter.

Try to perform the same experiment with the tumbler half full of water. '*Why does it fail?*' '*On how many sides of the*

paper was the air the first time?' 'On how many the second time?'

(3) Fill the tumbler with water and cover it as before. Invert with the mouth under water. Remove the paper. Question out why the water remains in the tumbler. Emphasise the fact that the pressure of the air *on the surface of the water* in the dish is transmitted to the water in the tumbler.

(4) The wine-tester. This is a tin tube terminating in a small cone, the end of which (*o*, Fig. 83), is open. There is an opening at the top. The tube is immersed in the liquid to be tested, and filled. The upper end is closed with the thumb, and the tube withdrawn. The upward pressure of the air at *o* keeps the liquid in. When the thumb is raised the liquid runs out. '*Why?*'

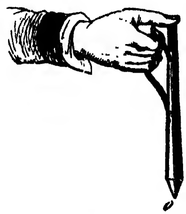


FIG. 83.

(5) Another illustration of the same principle. A number of small holes are made in the bottom of a tin can (B, Fig. 84), and a hole is also made in the cork (A). The can is filled, and as long as the thumb is kept on the mouth the water remains, but when the thumb is removed the water runs out at the bottom.

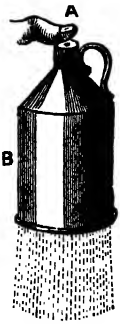


FIG. 84.

(6) Place one end of a tube in water. Suck out the air, and the water rises in the tube. '*Why?*'

(7) The same effect is produced when the nozzle of a syringe is placed in the water and the air is withdrawn by means of the piston. [Show.]

Barometer.—Take a glass tube about a yard long and a quarter of an inch in internal diameter. Close one end by holding it in the flame of a Bunsen burner. [Proper barometer-tubes may be bought ready.] Fill the tube with mercury; then place the thumb on the mouth (C, fig. 85) and invert the tube (A B) in a small mercury trough. The mercury in the tube sinks till the column is about 30

inches high, and then remains stationary. Elicit that the mercury is kept in the tube by the pressure of the air on the surface of the mercury in the trough. Elicit (1) that there is a vacuum at the top of the tube; (2) that pressure is therefore exerted in only one direction; (3) that the height of the column varies with the weight of the air. This is the principle of the *barometer.*

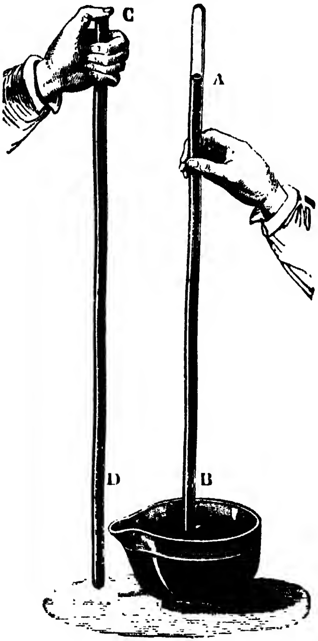


Fig. 35.

Fig. 86.

Wheel barometer.—Common barometers generally consist of a bent tube, with a long arm closed and a short arm opened at the end. There is a vacuum at the top of the long arm, and the mercury is kept up by the pressure of the air on the surface in the short arm. The height of the column is generally shown by a needle on a dial. The float (Fig. 86, *a*) rises and falls with

the mercury. A string attached to the float passes over a pulley, and has at the other end a weight (*b*) somewhat lighter than the float. The needle (*c*) is fixed to the pulley, and moves round as the mercury rises or falls.

What a barometer tells.—A barometer really tells not what the weather will be, but what the weight of the air is. At the same time there is some connection between the two things, because when the pressure is high we are more likely to have fine weather than when the pressure is low. The scale on common barometers is—

Height	State of the weather
31 inches	Very dry.
$30\frac{2}{3}$ "	Settled.
$30\frac{1}{3}$ "	Fine.
30 "	Variable.
$29\frac{2}{3}$ "	Rain, or wind.
$29\frac{1}{3}$ "	Much rain.
29 "	Storm.

[There will be no need to make the children learn these numbers. It will be enough for them to remember that at 30 inches the weather is likely to be variable, above 30 fine, and under 30 wet. Ordinary weather-glasses are of little use for two reasons: 'The first is that they are neither very delicate nor precise in their indications. The second, which applies equally to all barometers, is that those commonly in use in this country are made in London, and the indications, if they are of any value, are only so for a place at the same level and of the same climatic conditions as London. Thus a barometer standing at a certain height in London would indicate a certain state of weather, but if removed to Shooter's Hill it would stand half an inch lower, and would indicate a different state of weather. As the pressure differs with the level, and with geographical conditions, it is necessary to take these into account if exact data are wanted.'—GANOT: *Popular Natural Philosophy* (Ed. Atkinson), p. 124.]

THE PUMP

[This lesson will be of little use unless illustrated by a model. The barrel must be made of glass, so that the action of the valves may be seen. These are not bound to be of the same form as in an ordinary pump, and the piston may work as in a syringe, without a lever handle.]

The Syringe.—Introduce the syringe once more. Push the piston to the bottom of the barrel, and place the nozzle in the water. Let the children think of the surface of the water as divided into two parts the part inside the syringe, and the part outside—and make perfectly clear that the air is pressing on *both.*

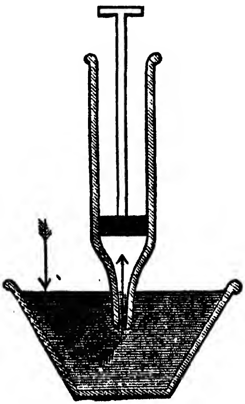


FIG. 87

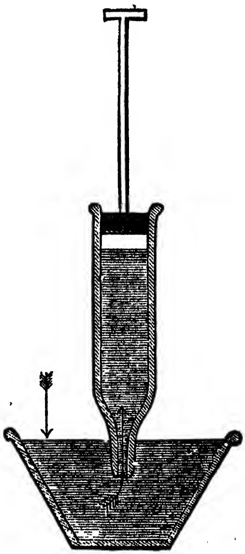


FIG. 88.

Pull up the piston. '*What has become of the air that was in the barrel?*' '*What has become of the little air that was between the piston and the water?*' Make clear that this has expanded so as to fill the whole barrel, and that therefore it can exert little pressure on the water inside the syringe. The external air

presses on the water outside the syringe, and the pressure is transmitted, causing the water to rise in the barrel.

The principle of the pump is the same as that of the syringe.

Suction or lifting pump.—The common suction or lifting pump consists of a cast-iron (or wooden) cylinder called the

FIG. 89.

barrel, at the bottom of which is a pipe of smaller diameter dipping into the well.

At the top of this pipe is fixed a *valve* which opens upward

like a trap-door. Make perfectly clear that the valve opens upward only.

The *piston* moves up and down the barrel. It consists of a disc of metal or leather coated with tow or leather. '*Why?*'

In the piston is a small hole closed at the top with a *valve* which also opens upward only.

The *piston-rod* is worked by a lever, which is the handle.

Action.—The action of the pump will be seen in the model. Record the observations by making drawings on the blackboard

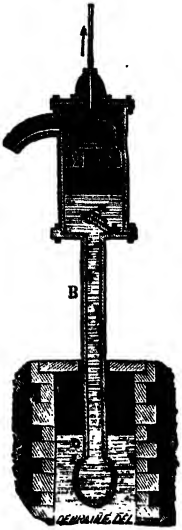


FIG. 90.

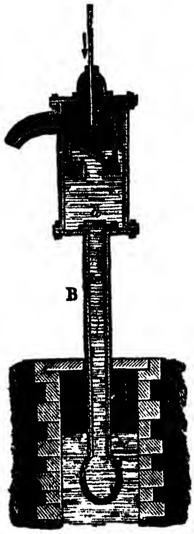


FIG. 91.

showing the position of the valves and of the water at different stages.

(1) When the pump is idle the barrel and the pipe are full of air under ordinary pressure, which counterbalances the pressure of the air on the surface of the well outside the pump. Hence the level of the water inside and outside is the same.

(2) When the piston rises (Fig. 90) the valve *c* is pressed down by its own weight and the weight of the air above it. Hence

a vacuum is created below the piston; but the air which fills the pipe B being elastic opens the valve *a*, and passes into the barrel. The pressure of the air inside the pipe being now less than the pressure on the surface D of the well outside, water rises in the pipe and through the valve *a* into the barrel (Fig. 90).

(3) If, now, the piston sinks (Fig. 91) the valve *a* closes ['*Why?*'], the air in the barrel is compressed, raises the valve *c*, and escapes into the top of the barrel. With the next ascending stroke of the piston the valve *c* falls ['*Why?*'], the valve *a* opens ['*Why?*'], and the water being thus raised in the pipe passes above the valve *a*, and completely fills the barrel (Fig. 91).

(4) From this time, when the piston redescends and the valve *a* closes, the pressure exerted on the water raises the valve *c*, and the water passes above the piston (Fig. 92).

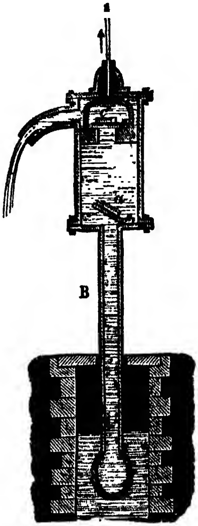


FIG. 92.

The valve *c* closes when the piston ascends, and the water which has passed above the piston being raised with it, flows out of the spout.

Height.—Refer to the part of the last lesson which dealt with the barometer, and see that the children clearly understand that the weight of a column of mercury equals the weight of a column of air of the same diameter. Then make clear that this principle applies to the column of water in a pump. But water is much lighter than mercury, and the pressure of the air is sufficient to hold up a column of water about 34 feet high. But in practice the vacuum produced in the barrel is never perfect, and so a pump will not raise water quite so high.

Force-pump.—If it is necessary to raise water higher, a force-pump is used. In this the piston P has no valve, and there is no lifting-pipe, the barrel being immersed in the water to be raised. There are two valves in the barrel: one, *a*, in the

bottom, opens upward ; the other, *c*, is placed at the mouth of a long tube H in the side of the pump.

When the piston rises (Fig. 93), a vacuum being created below it, the atmospheric pressure acts on *c* and closes it, while the water in which the pump is immersed being forced by its own weight and that of the atmosphere, raises the valve *a* and passes into the barrel, which it fills.

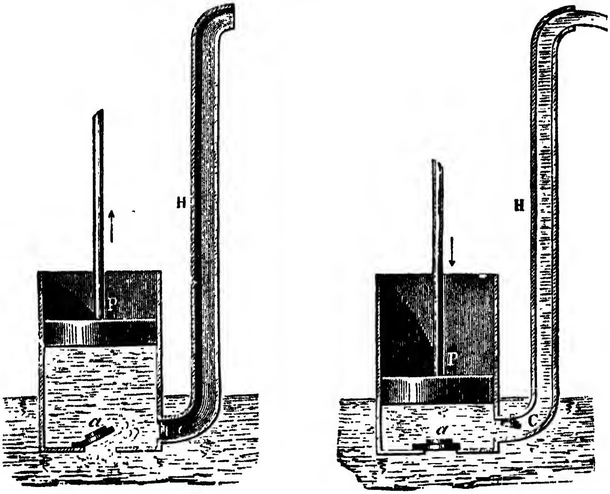


FIG. 93. FIG. 94.

When the piston descends, the valve *a* (Fig. 94) closes by its own weight and the pressure of the water above it, while the valve *c* opens and allows the water to pass into the pipe. The height to which it will rise in the pipe depends upon the force with which the piston descends.

EQUILIBRIUM OF LIQUIDS.

Surface of liquids.—Fix a string horizontally. See that the children know the meaning of *horizontal.* Hold a water-bottle or other glass vessel containing water so that the surface

of the water shall be on a level with the string. Make the children note that the surface is horizontal, and that it remains so however the vessel may be tilted. [Two exceptions may be ignored: (1) The surface of a liquid in a small tube is curved by capillary force; (2) the surface of a large mass of water, such as the sea, does not form one single perfectly plane surface, but a series of plane surfaces inclined to each other.]

Level in communicating vessels.—When vessels containing the same liquid communicate with one another the level of the liquid is the same in each.

This is often illustrated by a special apparatus, like that

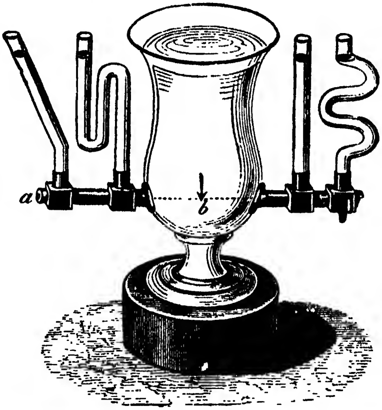


FIG. 95.

shown in Fig. 95, which makes clear the fact that uniformity of level is independent of the size or shape of the vessels.

If special apparatus is not available and a substitute cannot be constructed, illustrate by means of a tea-pot. The level is the same in the pot and in the spout whatever may be the position in which the pot is held.

Applications.—(1) *The water-level.*—In the construction of railways, canals, and roads it is often necessary to find the difference in level between two places. The simplest apparatus employed is the water-level, which consists of a metal tube

bent at each end, with glass tubes fitting into the bent ends. When the liquid is at rest the level in both tubes is the same. Fig. 96 shows how the apparatus is used.

FIG. 96.

(2) *The engine-gauge.*—This enables a driver to see how much water is in his engine. The gauge consists of a glass tube placed outside the engine, and communicating at each end with an opening in its side. [The stop-cocks (E and F, Fig. 97) are used to break the communication when a new gauge has to be fitted.] The water in the gauge stands at the same height as that in the engine.

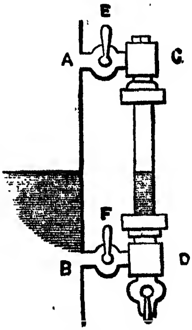


FIG. 97.

(3) *Fountains.*—Get two or three yards of indiarubber tubing. Fix one end over the spout of a can and in the other place a nozzle (which may easily be made out of a little piece of glass tubing). Fill the can with water, and let some run into the indiarubber tube, the nozzle pointing upward. If the can is lower than the nozzle, no effect is apparent; if the can is higher, we have a jet of water from the nozzle.

Apply this to actual fountains. The can is the reservoir, which must be as high as the top of the jet—in fact, a little

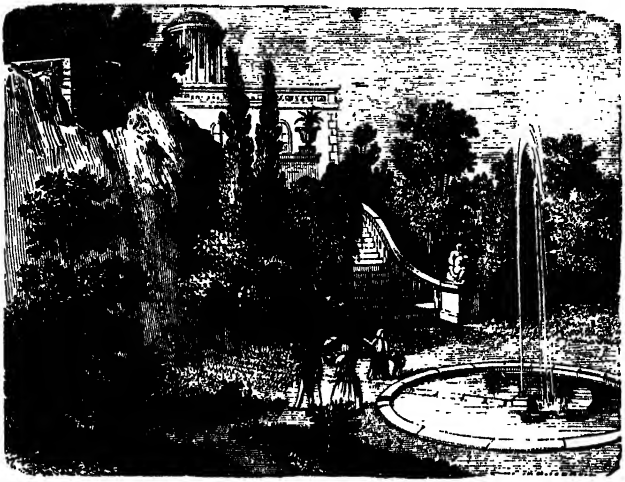


FIG. 9

higher, for the friction of the pipe and the resistance of the air have to be overcome.

(4) *Waterworks.*—Apply the same illustration to water-works, letting the can stand for a reservoir or water-tower and

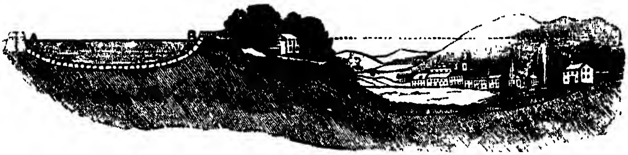


FIG. 99.

the nozzle for a tap. If a reservoir cannot be constructed on ground higher than any point to which water has to be supplied, a tower is built or a great pipe is made higher, and the water is first forced to the top and then allowed to run hence.

CAPILLARY ATTRACTION

[The way in which capillary force acts depends upon whether the liquid (like water) does or (like mercury) does not moisten the tube. In this lesson only liquids that moisten will be dealt with.]

Illustration.—Place a little coloured water in a saucer or other shallow dish. Immerse in it the lower ends of several glass tubes of very narrow bore ('capillary tubes'). Make the children note—

(1) That the water rises in each tube.

(2) That it rises highest in the narrowest.

Capillary.—The channels in the little tubes being hair-like are called 'capillary' (Latin *capillaris*, hair-like, from *capillus*, hair). If any substance containing hair-like openings or pores is placed in a liquid, the liquid passes up the openings. The force drawing it up is called 'capillary attraction.'

Other illustrations.—Place two rectangular pieces of glass of equal size face to face. Separate the upper edges by means of a narrow strip of thick paper. Immerse the lower edges in the coloured water, which will rise between the two pieces of glass. The height to which it will rise will vary with the thickness of the strip of paper.

Place in the coloured water pieces of bread, sugar, salt, sponge, and other porous substances, and the ends of a strip of blotting-paper, and of a piece of cane. The water will rise in each through the openings, which are, in effect, the same as the channels in the capillary tubes.

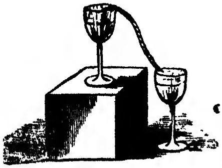


FIG. 100.

FIG. 101.

Place two wine-glasses on different levels. Into the higher pour some coloured water. In this insert one end of a piece of cotton wick. Let the other end dip into the lower glass, and the water will quickly pass into it.

Applications.—Perhaps the most common application of capillarity is seen in a paraffin lamp. Amplify.

A similar application is seen in a burning candle. (See p. 139).

Plants growing in pots are often watered by water being poured into the saucer.

The same principle is applied in hyacinth pots (Fig. 101).

MAGNETS

Magnetic attraction.—Show that a magnet will attract pieces of iron and steel.

Polarity.—Plunge the two ends of a bar magnet into iron filings. [The box or bottle containing the filings should stand on a large sheet of paper, so that the filings will not be spilled

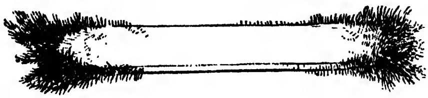


Fig. 102.

on the table.] The filings will adhere in a tuft to each end of the magnet.

Perform the same experiment with iron tacks.

These experiments show that the magnetic power resides chiefly at the ends of the magnet. These are called the *poles*.

The experiments also show that the magnetic power is transmitted. One steel pen will not attract another, but the first, if held up by the end of a magnet, will in its turn hold up the second.

North-seeking and south-seeking.—Balance a bar magnet

in a small paper stirrup suspended from a single fine cord which does not untwist of itself (such as horse-hair, cat-gut, or carefully woven silk fishing-line). If we do not let the magnet turn round so as to twist the cord it will always come to rest in one particular position. [There should be no draughts, and all iron should be removed from the neighbourhood.] The magnet will always be found to point north and south, and the same end will always be found to point in the same direction. The ends are called *north-seeking* and *south-seeking*. Find the north-seeking ends of two bar magnets, and gum a piece of paper on each. [If preferred, the north-seeking end of a bar magnet may be discovered by laying the magnet on a piece of cork floating in water.]

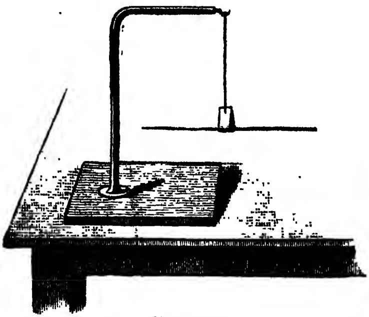


FIG. 103.

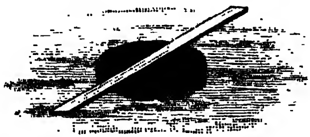


FIG. 104.

Attraction and repulsion.—Suspend one of the bar magnets. To its north-seeking end bring the north-seeking end of the other. It will be found that the two ends repel one another.

Bring the south-seeking ends together, and the same effect will be observed.

Now bring the north-seeking end of one up to the south-seeking end of the other, and it will be found that they attract one another. *Like poles repel; unlike poles attract.*

To make a magnet.—Suppose we want to make a magnet of a steel knitting-needle. Lay the needle on the table and stroke it several times *in the same direction* with *one* pole of a bar magnet. Prove that the needle is a magnet by dipping the ends in iron filings.

Parts of magnets.—Every part of a magnet is a magnet. Break into several pieces the needle just magnetised, and show that each piece is a magnet.

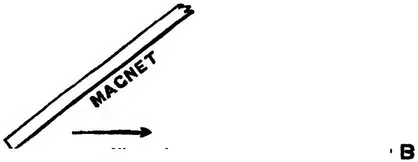


Fig. 105.

The mariner's compass.—One of the most important practical applications of magnetism is the mariner's compass, but there will be no time to describe it in this lesson. It should, if desired, form the subject of another lesson.

B: General Lessons on Natural History

MAMMALS

Classification.—Write on the blackboard the names of some of each kind of creature dealt with in the preceding lessons, such as the cat, dog, horse, cow, hen, duck, herring, frog, crocodile, snake, butterfly, bee, spider, snail, and earth-worm. Ask the children to separate the creatures that have bones from those that have none, and write the names in two columns Direct attention to the boned animals, and ask in each case on what they feed their young. Write by themselves the names of all animals that feed their young on milk, such as the cat, dog, horse, and cow. Ask for others of the same kind. All animals that feed their young on milk are called *Mammals*.

Warm-blooded.—Ask what children have felt a cat, a dog, a bird, a fish, and a frog. Emphasise the fact that the mammals and the bird were warm, the fish and the frog cold. Mammals and birds have warm blood, fish and reptiles cold.

Air-breathing.—Ask the children with what they breathe. Illustrate the action of the lungs. The oxygen which we take

into the lungs purifies the blood and warms it. All mammals breathe air by means of lungs.

Limbs.—'*How many limbs have we?*' '*What are they?*' '*How many limbs have monkeys?*' The four are called hands. '*How many limbs has a dog?*' '*What are they?*' Question similarly about other mammals, and thus bring out the fact that most of them are four-footed.

Coverings.—Ask questions about the coverings of various mammals, such as the cat, dog, horse, sheep, pig, elephant, camel, bear, and beaver, and thus bring out the fact that nearly all mammals are clothed in hair—which may take the form of wool, as in the sheep; of bristles, as in the pig; of fur, as in the beaver; and of spines, as in the hedgehog.

Jaws.—Make the children consider the action of their own jaws, and thus find out that the upper one is fixed and the lower movable. This is the case with other mammals.

THE WHALE

Not a fish.—Though the whale lives entirely in the water it is not a fish. Emphasise the differences—

(1) Whale breathes by lungs; a fish by gills.

(2) Fish have scales; whales have not.

(3) Fish have cold blood; whales have warm.

(4) Young fish come out of eggs; young whales do not.

(5) Whales feed their young on milk, and therefore are mammals.

Breathing.—A whale breathes air as other beasts do, and would drown if kept under water too long; but it can remain under water for an hour at a time. The air that we breathe passes into our lungs and makes our blood pure. If we did not have a constant supply of fresh air our blood would become poisonous and we should die.

When the whale comes to the surface it 'spouts' out from its nostrils a shower of spray made up of the water lurking in them, the vapour of the breath, &c. It then takes in as much air as it can.

In the body of the whale are a large number of blood-vessels of a peculiar kind. In these the blood purified by breathing is stored up, and does not pass into the rest of the body till needed.

The nostrils are closed under water. '*Why?*'

'Flippers.'—Mammals generally have four limbs. The hind legs in the whale have almost disappeared, though there are under the flesh small bones showing where they would be. The fore legs (or 'flippers') take the place of fins in fishes. They are furnished with a kind of hand covered with a thick skin, and are chiefly used to balance the animal. Explain.

Tail.—The tail of the whale is horizontal, not vertical like the tails of fishes. [There will be no need to use the terms 'horizontal' and 'vertical,'—'flat' and 'upright' will do. Illustrate with the hand.] It is very large and powerful, and is used in driving the whale through the water.

Where found.—Whales live in cold seas.

Blubber.—Fish being cold-blooded do not need to be kept warm. The whale is kept warm by a very thick layer of fat (called 'blubber') which is found beneath the skin, and hinders the heat of the body from escaping. The blubber also makes the animal light. Show that fat will float on water.

Size.—The whale is the largest of living creatures. It is from 60 to 70 feet in length, and from 30 to 40 feet in girth. The head is over 20 feet long. Make these numbers concrete.

Eyes.—Small; not larger than those of an ox. Elicit that, living in the water, the whale does not need keen sight.

Ears.—Also small, because sound is carried much better through the water than the air.

Throat.—Only a few inches across. Sailors say that a penny loaf would choke a whale.

Food.—The whale does not need a large throat because it feeds on a kind of ocean snail not more than an inch in length.

Whalebone.—Eating small, soft food the whale needs no teeth. The upper jaw is covered all round the edges with horny plates of 'whalebone' fringed with bristles instead of teeth. Show whalebone. In feeding, the whale, opening its mouth, takes in a mouthful of sea-water and its animal

contents; then, closing the jaws and pressing the tongue against the roof of the mouth, it drives out the water through the slits between the whalebone plates.

FIG. 106.—Head and tongue of Whale. *a*, tongue (represented much too large); *b*, whalebone plates.

The whale 'fishery.'—The whale is sought because of its blubber and its whalebone. A large one is worth more than 1,000*l*. Describe as graphically as possible the various incidents in the capture.

THE BAT

FIG. 107.

[The best illustration will be a bat, living or dead, which may be procured with a little foresight and a little luck. A picture of the skeleton will be useful.]

Food.—The bat lives on gnats, moths, &c. These fly about in the dusk on warm days. Elicit thence—

(1) That the bat must be able to fly, and to fly faster than the gnats, &c.

(2) That, as there are no insects to be caught in winter, the bat must either sleep like the bear, or go to warmer countries like the swallow.

Hibernation.—Towards the end of autumn the bat (like the bear) grows very fat. At the first signs of cold weather it retires to some hiding-place, such as a barn or hollow tree. There it hangs head downward by the claws of its hind feet, folds its wings around it, and falls into a kind of half-dead condition.

Not a bird.—By questions and by showing the specimen get out that a bat differs from a bird—

(1) It is covered with fur, not feathers.
(2) Its wings are made of skin.
(3) It lays no eggs.
(4) It feeds its young on milk, and therefore is a mammal.

Body.—Shape and covering like a mouse's.

Teeth.—Small, but very sharp. The bat therefore cannot chew the insects that it catches, but it makes a series of short, snapping bites at them.

FIG. 108.—Head of Bat.

Nose.—Often flat, and covered with what is called a 'leaf.'

Ears.—The bat most common in the British Isles (the long-eared bat) has ears almost as big as its body.

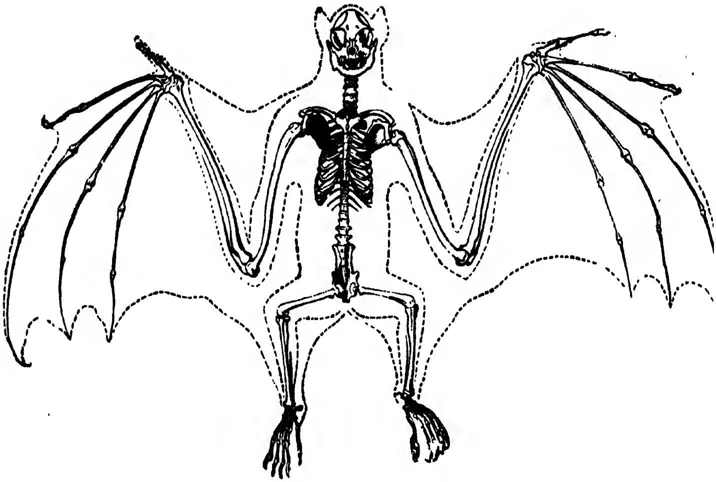


FIG. 109.—Skeleton of Bat.

Arms.—Show picture of skeleton. Compare the arms to our arms, but enormously larger in proportion. If our arms were as large in proportion as those of the bat our elbows would reach to our knees while our wrists were on the tops of our heads, our hands would be nearly as long as our bodies, and the joints of our fingers half as long.

Legs.—The legs are of about the same size as those of a mouse. At the ends of the toes are the claws or hooks by which the bat hangs. From the heel runs a long, pointed bone.

Wings.—Compare the bony framework of the arms to the ribs of an umbrella, and the membrane forming the wings to the silk.

The wings are made of skin, rather thick near the body, but very thin near the edges. It stretches from the fingers to the shoulders, and from them to the heels and tail.

The wings are so large that when the bat is standing on the ground it cannot raise itself by them. It climbs up a wall or

tree by means of its sharp claws, and then drops, spreading its wings as it falls

Eyes.—'As blind as a bat.' The bat is not blind, but its eyes, not being formed for use by day, are dazzled by a bright light. Compare to the owl, and in some degree to the cat.

Still, the sight of the bat is not very good even in the dusk, but it is able to fly about safely among thick branches of trees in the dark. The sense of feeling in the wings is so very sharp that the animal can, by their help, tell when it is coming near anything.

BIRDS

[A hen or some other living bird would be very useful for purposes of illustration.]

Mammals and birds.—By means of questions get from the children some of the differences between mammals and birds, such as—

(1) Birds lay eggs; mammals do not.

(2) Mammals feed their young on milk; birds do not.

(3) Mammals generally have four feet; birds have only two feet, the front limbs being wings.

(4) Mammals are generally covered with hair (in some form); birds with feathers.

(5) Mammals generally live on the ground; most birds spend much time in the air.

Bones.—Elicit that in order to rise into the air birds must be light. The bones in mammals are solid and heavy. The larger ones are hollow, but they are filled with marrow. The bones of birds are hollow [Show] and filled with air. Strength and lightness are thus combined. Compare with the stalks of corn, the 'backbone' and 'forks' of a bicycle or tricycle, and the piers of an iron bridge.

Breathing.—The hollows in the bones are connected by openings with certain air-vessels leading into the lungs. When a bird breathes, therefore, air enters all the bones. More than that, the lungs of a bird differ from those of a mammal. The

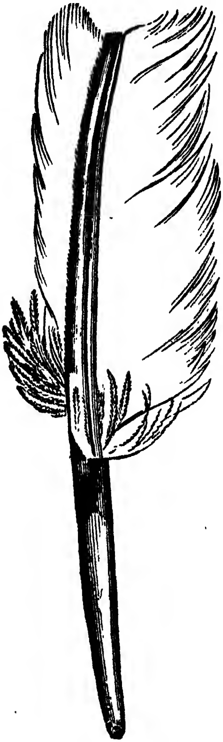
greater part of the chest, the back, and the spaces between the ribs are filled with air-cells into which the lungs pump air.

The great quantity of air inside a bird accounts for—

(1) The lightness of the body.

(2) The loud and long-continued song of birds. Compare the air-cells to the bellows of an organ.

(3) The long time that diving-birds can stay under water.



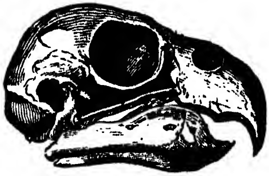


FIG. 111.—Skull of Parrot.

FIG. 112.—Head of Eagle.

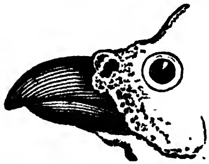


FIG. 113.—Head of Numida.

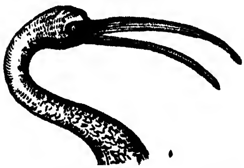


FIG. 110.—Contour-feather.

FIG. 114.—Head of Ibis.

Feathers.—Let a child feel the living bird, or ask who has felt one. The body is very warm. The warmth arises from the large amount of oxygen breathed. The coldness of fish

and reptiles arises from the opposite cause. The warmth of birds is kept in by the feathers. Elicit that the warmest quilts are made of down.

All birds have feathers, and no other creatures have any. Show the two kinds ('down-feathers' and 'contour-feathers'), and get out by questions that the former are for warmth alone, the latter for flight also.

Beaks.—Nearly all mammals have soft lips and hard teeth. Birds have neither. Their beaks or bills vary with their food. Compare the strong, curved beak of an eagle or a hawk with the short, stumpy beak of a hen and the soft, spoon-like bill of a duck.

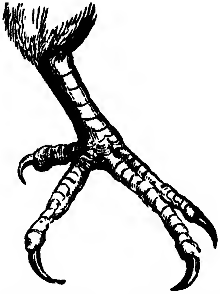


FIG. 115.—Foot of Woodpecker.

FIG. 116.—Foot of Eagle

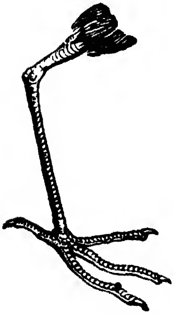


FIG. 117.—Foot of Ibis.

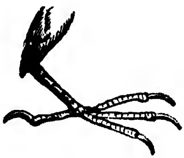


FIG. 118.
Foot of Perching Bird.

FIG. 119.—Foot of Pelican.

Feet.—Make a similar comparison between the feet of various classes of birds.

FISHES

[Show the structure of the gills by means of a dead fish, and their action and the action of the fins and tail by means of a living fish in a glass vessel.]

Breathing.—Every part of a fish fits it for living in the water. Mammals, birds, and reptiles breathe oxygen from the air. If kept under water they would die for want of oxygen. Even such an animal as the frog could be drowned in time.

In all ordinary water there is a certain amount of air. Boil a little water in a test-tube, and make the children note the many bubbles of air that pass up out of it. If this water were allowed to cool, a fish placed in it would die.

Fish, then, breathe the air found in water, but they could not breathe it by means of lungs.

Show the gills. Make the children note the red colour. Elicit that this is the colour of the blood, and that the walls of the blood-vessels must be very thin. Also make the children note how a large surface is obtained by the many walls of the gills.

Fishes open their mouths to take in water, then, closing their mouths, they drive it out over the gills. Show the action of the mouth and gills in the living fish. As the water passes out the air in it acts upon the blood.

Cold-blooded.—Question on the two preceding lessons, and make the children see that mammals, which breathe a large amount of oxygen, are warm-blooded, while birds, which breathe still more air, are still more warm-blooded. Hence elicit that fish must be cold-blooded. Let a child feel the living fish.

Scales.—Question on the coverings of mammals and birds, and bring out the fact that hair and feathers are wanted to keep in the warmth of the body. Hence elicit that fishes, having no warmth to keep in, need neither hair nor feathers. They are covered with scales. Show, and call attention to the way in which they are arranged. Elicit that if the 'tiling' were in the opposite direction it would hinder the motion.

Let a child feel the living fish to find out that a kind of

slime comes off on the hand. This oozes out of small holes in the scales, and acts like oil, keeping out the water.

Shape.—Show how the shape of a fish adapts it for cutting through the water. Compare to the shape of a racing-boat and of a swallow's body.

Motion.—The motion is caused by the action of the tail. Compare to the action of the screw of a steamer, or to the propelling of a boat by an oar at the stern.

Show the fins, and explain that their purpose is to balance the body.

Food.—Most fishes eat other fishes, or whatever living things come in their way.

Teeth.—Elicit that their jaws must therefore be furnished with teeth. Show picture of a shark's teeth.

Eggs.—Most fishes lay many thousands of eggs. Show (or refer to) the hard roe of a herring, which is made up of eggs. These are laid in the shallower water. This being warmer than the deeper water, they are hatched there.

REPTILES

[Have pictures of tortoise or turtle, lizard or crocodile, and serpents. It would be an advantage to have a real tortoise, lizard, or frog.

Frogs and toads are often called reptiles, and they resemble true reptiles in most respects, but differ from them in their mode of growth. The young of a true reptile is like its parents from the first; the young of a frog or toad begins life as a fish. Frogs and toads are therefore classed by themselves as *batrachia* (Gr. Βάτραχος, a frog), but either may be used in illustrating this lesson.]

Creeping animals.—Ask questions about the length of a crocodile's legs, of a turtle's, and of a serpent's. Thus impress on the children the fact that the animals about which they are going to hear must generally creep or crawl. The word *reptilis* in Latin means creeping; hence such animals are called *reptiles*.

Cold-blooded.—Let child feel, or ask who has felt a tortoise, lizard, or frog. People say, 'As cold as a ——.'

Reptiles are cold-blooded. '*What other class of animals is cold-blooded?*' '*Why are fishes cold-blooded?*' Fishes breathe only the air in the water, and as there is very little of that, very little oxygen can get to their blood. Reptiles breathe by means of lungs, but both their lungs and their hearts differ from those of mammals and birds, and are so made that no large quantity of oxygen can get at the blood. Hence reptiles are cold-blooded.

Coverings.—Elicit, as in the case of fishes (see p. 214), that reptiles, being cold-blooded, do not need hair or feathers.

Serpents are covered with scales, which help them to move. These not being a part of the true skin, are shed and replaced.

In animals like the tortoise and turtle the scales make a very hard shell, and in the crocodile they make a covering very difficult to pierce.

Senses.—Question on the food of crocodiles, serpents, and frogs, and elicit that as it is swallowed whole reptiles do not require to have any sense of taste. The tongue is used for feeling rather than for tasting. Refer to the action of a frog's tongue (see p. 151) and a snake's (see p. 156).

'*How many eyes has a reptile?*'

Eggs.—All reptiles lay eggs, which are generally hatched by means of the sun. As soon as hatched the young reptile is of the same shape as its parents. Hence frogs and toads are not true reptiles.

INSECTS[1]

[Sufficient matter is provided for two lessons.

Specimens of insects would be useful for purposes of illustration, but as no specimen could be seen by the whole class at once, large pictures of a few typical insects should also be provided.]

No skeleton.—'*What is it that feels hard when we press on a mammal?*' [Bones.] '*Are there any bones in a bird?*' '*A*

[1] The greater part of the matter of this lesson is taken from the Rev. J. G. Wood's *Natural History Reader*, Book VI.

fish?' '*A reptile?'* If any insects have been provided, let a child feel them. They have no bones.

Rings.—Every insect is made up of thirteen rings. Show rings in the specimens and on the pictures. [The thirteen cannot be distinguished.] In a large caterpillar (which is an insect in one form) the thirteen rings can be easily seen, but without a microscope only eight or nine could be seen in a fly or a beetle.

Let one of the children take a deep breath, and make the rest observe that the chest becomes larger. Elicit that it could not stretch if it were surrounded by unyielding rings. So with an insect.

Each ring, therefore, is made up of two semicircles joined by a strong elastic skin, which stretches when the insect is breathing or eating.

Parts.— Let the children note the deep cuts in an insect. '*How many?'* [Two.] '*Into how many parts can an insect be divided?'* [Three.] Show picture or specimen, and ask into how many parts a spider can be divided. [Two.] All insects can be divided into three parts—the head, the chest, and the abdomen. The spider, therefore, is not an insect. The word 'insect' comes from two Latin words meaning 'cut into.'

Legs.—Every insect has six legs, which are joined to the lower side of the middle part of the body (the chest). Each leg consists of three parts—the thigh, the knee to the ankle, and the foot (with several joints).

Sometimes it is difficult to see the six legs, as one pair of them is very small. This is the case in the butterfly, for instance.

Wings.—Every insect has four wings joined to the upper side of the middle part (the chest).

Sometimes it is difficult to see the four. In the house-fly and the 'daddy-longlegs,' for example, the hinder pair seems absent; but if we look closely we shall see what look like two little stumps of wings. These are called 'balancers,' and, small as they are, the insect could not do without them. If they are damaged it cannot fly, but flutters helplessly about.

When a beetle is walking only one pair of wings can be

seen, and they are so stiff and hard as to appear useless for flight. They are, in fact, useless for the purpose. They are called 'wing-cases,' and serve to protect the flying wings, which when idle are packed away beneath them.

Elicit that as beetles creep under stones and other hard things, their delicate wings would be injured if deprived of the covers.

Skin.—Elicit that as insects have no bones, they would be soon crushed if there were not something (comparatively) hard around them. This is their skin, which, being both hard and elastic, protects them without preventing their bending.

Compare the action of the rings in bending to that of a railway train rounding a curve.

Circulation.—'*What pumps the blood through our bodies?*' Insects have no hearts, but just under the back is a long, narrow vessel each end of which is open. The blood passes through this, works its way between the various organs of the body, and then once more enters it.

Breathing.—'*With what do we breathe?*' Insects have no lungs. If we look through a microscope we shall see in the sides of an insect a number of holes. Each of these leads into a tube which runs the whole length of the body, sending off a number of branches to all parts. The air enters by the little holes in the sides, and thus passes through all the tubes.

Eyes.—Refer to the lesson on the Butterfly (p. 158). The eyes there described are typical. Repeat the description.

Sense of smell.—Insects have no noses, but their sense of smell is very keen. Those that feed on dead animals are attracted from great distances. It is not known how they can smell; some people think it is by means of their 'feelers.'

Changes of form.—As an illustration of the development of insects, repeat what was said under this head in the lesson on the Butterfly (p. 158).

TEETH

[Illustrate the action of ordinary incisors with a knife, of the incisors of rodents with a chisel, of canine teeth with two long, sharp nails or two awls, and of molars by two flat, nearly smooth stones and two flat, rough stones.

The skulls or teeth of different classes of animals would be of great use.

Refer constantly to the children's own teeth.]

Kinds of teeth.—Provide a piece of meat, some vegetables, and grains of corn. Show—

(1) That the meat and vegetables can be cut with a knife, but that the grains cannot easily be cut.

(2) That the grain and vegetables can be ground between stones, but that the meat cannot.

(3) That the meat can be torn with the nails or awls, but that the grains cannot, and that the vegetables are more easily cut than torn.

(4) That to make a fair-sized hole in a piece of wood a chisel is needed.

Our front teeth are formed for cutting. '*Why are cutting teeth always in front?*' Compare the edge to the edge of a knife.

Animals that gnaw have in front of each jaw two very long chisel-shaped teeth. It is by means of these that a mouse can cut its way through wood.

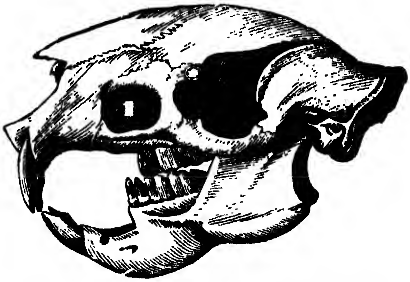


FIG. 120.—Skull of Porcupine (a gnawing animal).

On each side of our cutting teeth is a rounded, rather sharp-pointed tooth. Show. In animals that live on flesh (such as the cat, dog, lion) these teeth are very long and sharp.

Behind the tearing teeth we have flat teeth, which are used for grinding our food. Illustrate their action.

The teeth of mammals are generally of the three kinds named —cutting, tearing, and grinding.

Teeth and food.—If we saw the teeth of an animal we could tell on what it feeds, or if we knew on what it feeds we could tell the kind of teeth it has.

'On what does a cow feed?' 'What kind of teeth must it have in front?' 'Why?' 'And what kind of teeth must it have behind?' 'Why?'

Ask similar questions about the cat (flesh), pig (flesh and vegetables), and other familiar animals.

Flesh-eating mammals.—Show skull or picture of the teeth of a flesh-eating animal. Call attention to the very long and sharp tearing (canine) teeth. Show that the cutting teeth are very small. *'Why?'* Perfectly flat grinding teeth would not be of much use for flesh; hence the grinding teeth in the cat and similar animals have sharp and jagged edges.

Flesh- and vegetable-eating mammals.—In the bear and other animals that live on flesh and vegetables some of the grinding teeth have smoother crowns. There is also a difference in the action of the jaws. In flesh-eaters the jaw moves up and down only. *'In how many ways does our lower jaw move?'* Show that when grinding food our jaw moves sideways. The jaw of the bear moves sideways as well as up and down.

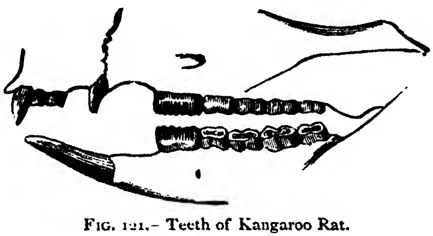


FIG. 121.– Teeth of Kangaroo Rat.

Vegetable-eating mammals.—The cow has broad cutting teeth in the lower jaw, and in the upper jaw neither cutting nor tearing teeth. (See p. 60.) The grinding teeth are broad and

flat. In some cud-chewing animals (the deer, for instance) the grinding teeth have little knobs of enamel (the hardest part of the tooth) on their surface. '*What is the use of these?*'

Gnawing mammals.—Show skull of mouse, rabbit, or hare. Call attention to the two long, sharp, chisel-like teeth in front of each jaw. These wear away with constant use, but they grow again at once. Furthermore, the front of the tooth is made of harder material than the back; hence the back wears away faster and the edge is always keen.

FIG. 122. Crown of tooth of Deer, showing the enamel crescents.

Gnawing animals do not need tearing teeth. The food which they cut with their front teeth is ground with their back teeth.

Mammals without teeth.—Some mammals have no teeth. Refer to the lesson on the Whale (p. 207); mention the food; show that teeth are not wanted, but that a strainer is.

The ant-eaters, again, living on insects, do not need teeth.

FIG. 123.—Skull of Anteater (a toothless animal).

Birds.—Birds have no teeth, their food being ground in the gizzard. To make the grinding more thorough many birds swallow little stones.

Reptiles.—Reptiles swallow their prey whole. Hence they need teeth to hold, not to tear or grind. Refer to what was said in the lesson on Snakes (p. 155). Some reptiles have no teeth.

Fishes.—Fishes also need teeth, chiefly to hold their prey. There is not so much variety in the teeth of fishes as in those of mammals.

COVERINGS

Why we need clothes.—By questioning on the preceding lessons remind the children that the oxygen of the air which we breathe, getting into the blood, causes the warmth of our bodies. '*Why is a "cosy" put over the tea-pot?*' Similarly we wear clothes to keep in the warmth of our bodies, and, in wintry weather, to keep out the cold. Elicit that in hot countries there is no need to keep out the cold, and therefore the clothing worn is very light. At the same time it must be warm to keep the body from being 'chilled' after becoming very hot.

'*What do people wear in very cold countries?*' [Furs.]

Winter and summer clothes.—Question about the changes which we, living in temperate climates, make in our clothing with the changing seasons. Animals cannot put on overcoats in the winter or leave them off in the summer. '*What do they do?*' Take the horse and sheep as examples. '*What keeps a horse warm?*' Ask whether the children have noticed how thick and rough a horse's coat becomes in winter. Horses living out-of-doors need this, but horses kept in stables do not. '*What is done to them?*' Their hair is 'clipped.' If it were not it would drop off gradually as the weather became warm.

Elicit that our warm clothes are made of the wool of the sheep, and that if we had to wear them in summer we should feel very uncomfortable. So would the sheep if it had to wear its wool. Consequently, towards the end of spring the wool is shorn. If the sheep were not shorn the wool would drop off.

Black things give off heat much sooner than white. Thus tea will keep hot longer in a white than in a black pot. So some animals become white in winter. The stoat, for example, is of a rich reddish-brown in summer, but in winter (when it is called the ermine) it is white.

Now take a few typical animals and show how their coverings fit them for their surroundings.

The elephant.—The elephant lives in warm countries and has a thick skin. It therefore does not require fur or hair. In

a wild state it is constantly moving through thick woods, and if it had any hair it would catch in the underwood. The same remark applies to the pig, which has no hair and not many bristles.

The beaver.—Refer to what was said about its fur in the lesson on the Beaver (p. 107).

The whale.—Elicit that as our clothes would not keep us warm in the water, a mammal like the whale has no fur. '*How is it kept warm?*' Refer to the lesson on the Whale (p. 207).

Protective colouring.—Refer to what was said on this point in the lessons on the Tiger and the Lion, the Rabbit, and the Crocodile (pp. 95, 96, 107, 152).

Birds.— Refer to what was said on the temperature of birds (p. 211), and elicit that as birds must fly and as their blood is very warm their covering must be both light and warm. '*We say "As light as a ——"?*' And if we want very warm quilts we line them with down. Thus impress on the children that feathers fulfil both requirements.

Fishes and reptiles.—By means of questions connect the fact that fishes and reptiles are cold-blooded with the fact that they have no hair, fur, feathers, or other warm covering.

C: Lessons on Elementary Botany

COTYLEDONS

[A week or ten days before the time for giving this lesson the teacher should plant a number of broad beans and grains of wheat or oats, in the garden if the season is suitable, in flower-pots if it is unsuitable. The flower-pots should be placed in a moderately warm room, and the soil kept moist. Two or three days later the teacher should plant some more beans, and two or three days later some more. Just before the lesson the germinated specimens must be pulled up for examination by the class. Also before the lesson soak some beans and wheat (or oats) for a few minutes in boiling water, and then distribute them among the children.]

Cotyledons.—Let the children examine the broad bean. At one end is a black stripe [*hilum*[1]]. This shows where the seed was attached to the carpel in which it was enclosed. Let the children squeeze the soaked bean, and a little moisture will come out through a very small hole [in the hilum].

Let the children next remove the skin. They will see that it contains two large thickened lobes or leaves flattened on the inner and rounded on the outer side, and hinged.

When the lobes are separated carefully there will be seen close by the hinge upon the margin of the inner face of one of them a rudimentary root and bud. The little root is called a

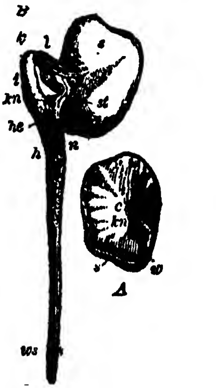


FIG. 124.- Broad Bean. *A*, seed with one cotyledon removed; *c*, remaining cotyledon; *kn*, plumule; *w*, radicle. *B*, germinating seed; *n*, hilum; *st*, petiole; *h*, main root.

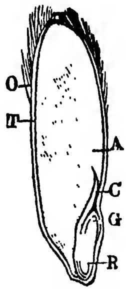


FIG. 125. Longitudinal section of Oat. *C*, the single cotyledon; *G*, plumule; *R*, radicle.

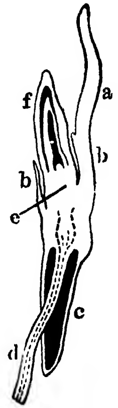


FIG. 126. – Germination of Oat; *a*, cotyledon; *d*, radicle; *f*, plumule.

radicle. It points towards the opening in the hilum, and growing forms the root. Show in the specimens.

The little bud is called a *plumule*, and growing forms the stem and leaves. Show.

The fleshy lobes or seed-leaves are called *cotyledons*. Plants which, like the bean, have seeds with two are called *dicotyledons*.

The grain of wheat or oat is rather small for examination.

[1] The technical terms enclosed in brackets are for the teacher, not the class.

Its structure will be made clearer by a drawing on the black-board. It will be seen to contain only one *cotyledon*. Plants which have such seeds are called *monocotyledons*.

Distinctions.—Most British plants—indeed, most of the plants of the world—are *dicotyledons*. Of the flowers examined in preceding lessons the buttercup, wallflower, primrose, dead-nettle, pea, daisy, and dandelion belong to this class. The tulip and daffodil are monocotyledons.

(1) Ask a few questions about the number of organs in the first class of flowers, and lead the children to see that the parts are usually in fours or fives (or multiples of four or five).

Similarly get out that in the second class the parts are usually in threes (or multiples of three).

(2) Next show the venation of the leaves. Dicotyledons are net veined, and monocotyledons are generally parallel veined.

Cut across a thick twig of any ordinary tree ; also cut across and along a piece of cane. The first is a dicotyledon and the second a monocotyledon. Make the children observe the differences.

(3) The first has bark, the second none.

(4) The first has central pith, the second none.

(5) The wood of the first is arranged in layers around the central pith. The wood of the second is arranged in fibres parallel to each other.

ROOTS

[Illustrate the first part of this lesson by showing either the roots of the plants named or other roots similar in form.]

Forms.—Call attention to some of the more common forms of roots, as—

(1) *Conical* ; like the carrot or monkshood.

(2) *Spindle-shaped* [fusiform] ; broadest in the middle and tapering towards the two ends, as in the radish.

(3) *Turnip-shaped* [napiform]; globular, with a tapering end, as in the turnip and some kinds of radish.

FIG. 127.—Conical root of the Carrot.

FIG. 128.—Spindle-shaped root of the Radish.

FIG. 129.—Turnip-shaped root of the Radish.

(4) *Fibrous*; giving off a number of slender branches, as in the grass.

FIG. 130.—Fibrous root of a Grass.

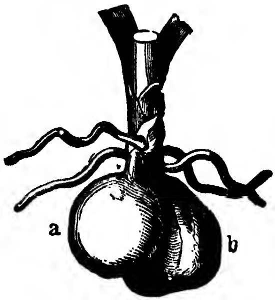


FIG. 131.—Double tuber (*a*, *b*) of *Orchis Morio.*

(5) *Tuberous*; when the fibres are swollen in an egg-shaped manner, as in an orchid [*orchis Morio*].

(6) *Palmate*; when the tuber is divided so as somewhat to

resemble the fingers of an outstretched hand, as in another orchid, the common *orchis maculata.*

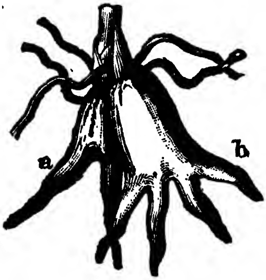


FIG. 132. · Double palmate tuber (*a*, *b*) of *Orchis odoratissima.*

(7) *Tufted* [fasciculated]; when there are a number of tubercles or fleshy branches arranged in a bunch, as in the dahlia.

FIG. 133.—Tufted root of Dahlia.

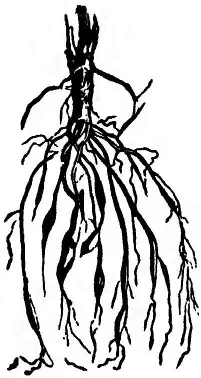


FIG. 134.—Nodulose root of Dropwort

(8) *Knotted* (nodulose); when the fibres are enlarged at the ends only, as in the dropwort.

Functions.—(1) To hold the plant firmly in the ground. Amplify.

(2) To convey food to the plant. A plant derives some of

its food from the air, and a great deal from the ground. The root cannot take in any substances from the soil so long as they remain solid, but it 'sucks' up substances that have been dissolved. Hence elicit the need of water to the life of a plant.

(3) Some of the substances in the soil will not dissolve in water, but will dissolve in an acid. The sap of plants is generally acid, and some of it, passing out through the roots, changes the food into the form in which it can be absorbed.

4. Some roots (such as the turnip) store up food. The turnip bears no flowers the first year, but the big root stores up the substances on which, during the second year, the flowers will live. After the plant has flowered and the seed ripened the root is found to be withered and shrivelled up. [When cultivated for food the turnip is pulled up during the first year.]

STEMS

Stem.—*Stem* is the name given to the part of a plant which bears the leaves and the flowers.

Two kinds.—Stems are either *woody* or *herbaceous*. Illustrate by specimens.

Roots and stems.—A few of the differences between roots and stems may be pointed out.

(1) Stems grow upward, roots downward.

(2) Roots are white; the stems of herbaceous plants are generally green.

(3) The 'growing-point' of the root is covered with a root-cap, and of the stem with young leaves (buds).

This may need some little explanation. If the tip of an uninjured root-fibre be examined through a magnifying-glass, the extremity of the fibre will be seen covered with a closely-fitting sheath, or root-cap. This cap is worn or withered as it forces its way through the soil, but it is constantly renewed from the inside by the growing-point.

The stem always begins in a bud. The first or primary stem begins in the plumule. Show again in the broad bean.

(4) The stems have leaves, flowers [and other *appendages*] differing from it in structure. The root simply has branches, the branches being the same in structure as the original root.

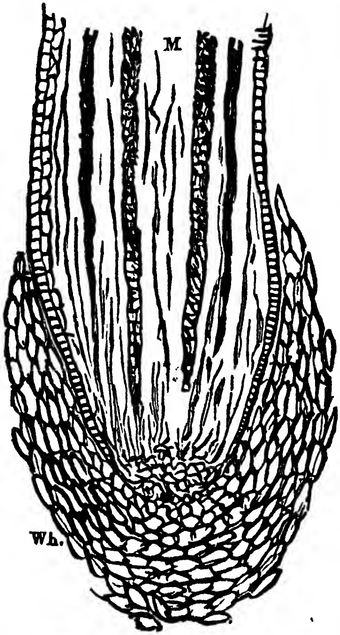


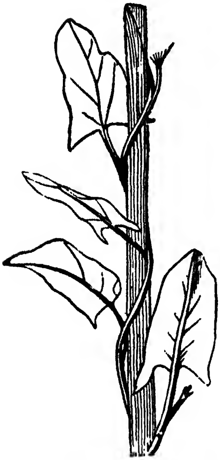
FIG. 135.—Longitudinal section through apex of a root; *wh*, root-cap; M, pith.

Forms.—(1) Make sections of different stems. Most of them will be circular, but a few may be angular.

FIG. 136.—Sections of angular stems.

(2) Most stems are erect, but some trail on the ground and some climb.

(3) Climbing stems attach themselves by rootlets (like the ivy) or by tendrils (like the pea), or they twine around their support (like the bindweed and the hop).



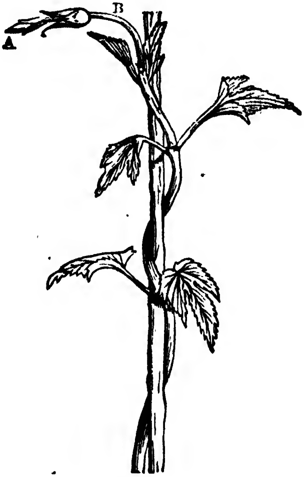


FIG. 137. Stem of *Convolvulus arvensis*. FIG. 138.—Stem of Hop.
[Note the different directions in which they twine.]

(4) *Runners*.—These may be seen in the strawberry. A branch springing from a plant creeps along the ground, strikes

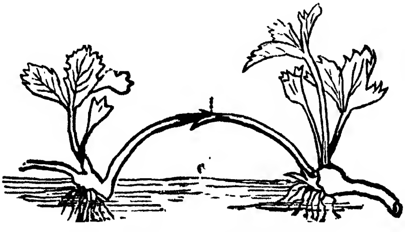


FIG. 139.—Runner of Strawberry.

in the soil, and produces leaves and roots, thus forming a new plant.

(5) Nearly the same kind of thing happens in gooseberries and currants. Gardeners imitate it in the process of 'layering,' when they bend down the branch into the soil, thus causing it to take root. [In the case of gooseberries and currants the 'runner' is called a *stolon.*]

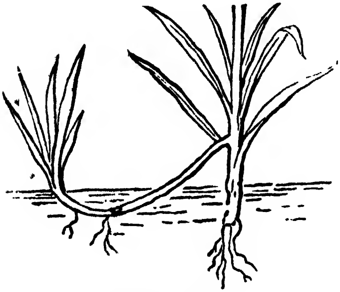


FIG. 140.—Stolon.

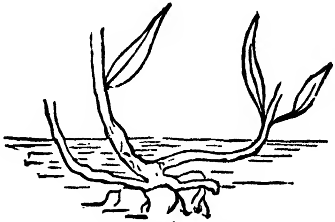


FIG. 141.—Sucker.

(6) *Suckers.*—In the gooseberry the branch that takes root springs above the soil. In the rose such branches spring beneath the soil, run a short distance, strike roots, and send up stems. These are called 'suckers.'

(7) *Root-stock* [rhizome].—In the iris or flag and in other plants there is a thickened stem which creeps either on the soil or just below it, giving off leaves from the upper surface and roots from the lower.

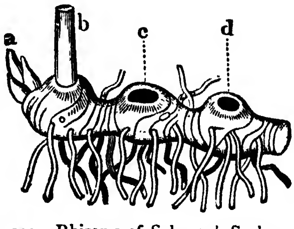


FIG. 142.—Rhizome of Solomon's Seal: *a*, terminal bud from which will be developed next year's stem; *b*, this year's stem; *c*, *d*, scars of the stems of previous years.

(8) *Creeping stem.*—This is thinner than the root-stock, but otherwise like it. It is seen in the sand sedge and in couch grass.

(9) *Tuber.*—The tuber is an underground stem or branch much swollen by starch, &c. It possesses leaf-buds. In the potato these are the 'eyes.' When the potato

is earthed the growth of the underground branches or tubers is encouraged.

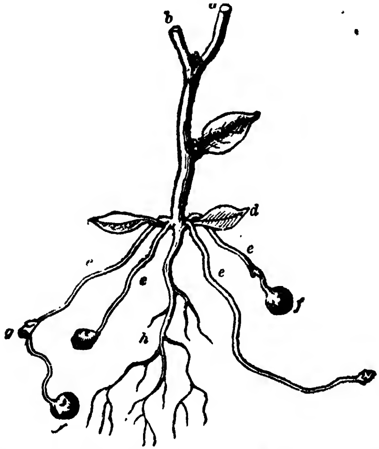


FIG. 143.—A six-weeks-old Potato plant, grown from seed: *a b*, the upper branches (cut off); *d*, cotyledons. In the axils of the cotyledons are developed the underground branches *e*, *e*, which bear tubers, *f*, *g*; *h*, true roots.

(10) *Bulb.*—Show in the onion.

(11) *Corm.*—A much more solid kind of bulb, seen in the gladiolus, snowdrop, crocus, &c. The bulb and the corm are seen only in monocotyledons.

Dicotyledons and monocotyledons.—Revise the differences already learned between the stems of these two classes.

LEAVES

[Two Lessons.]

Forms, &c.—Revise with proper illustrations the lessons on Leaves (pp. 120–127).

Functions.—(1) *To absorb food for the plant.*—Most of the substances on which plants live are taken up by the roots from the soil, but the carbon which they need is taken up by the

leaves from the carbonic acid in the air. Thus a gas which is poisonous to animals affords nourishment to plants.

(2) *To assimilate the food absorbed.*—The food that we eat builds up our bodies and repairs the waste in them, but the beef, mutton, bread, &c., must be changed to fluid before they are carried to those parts where they are wanted. Similarly the various substances taken up by the roots must be changed before they can build up the plant. They go up the stem as sap, which, when it comes in contact with the carbonic acid absorbed by the leaves, is changed into forms in which it can be assimilated. This process goes on only in the light; hence plants kept in the dark soon die.

(3) *As a breathing organ.*—The same process of respiration goes on in plants as in animals, but in a smaller degree. By day it is obscured by the assimilation process just described, but by night it can be distinctly perceived.

(4) *As an organ of transpiration.*—A large portion of the water taken in by the roots of the plant escapes by the leaves.

This process can be made visible. Pluck up a small plant by the roots. In the middle of a card make a hole large enough to allow the roots to pass through. Place the card over a tumbler of water, thus allowing the roots to dip into the water. Over the leaves place an empty tumbler, and this in a little while will be covered with the drops of transpired water.

The transpiration of plants causes the air in the neighbourhood of woods to be moist. Sometimes when a forest has been cleared the rainfall diminishes greatly and droughts are caused.

FLOWERS AND FERTILISATION

[Two lessons.]

[The first part of this lesson is a general summary of the lessons on Flowers (pp. 169–180). Every part should be illustrated by means of actual specimens.]

Whorls.—In a complete flower there are four circles of organs. Each circle is called a *whorl.*

Calyx.—The outer whorl is the *calyx*, which is made up of *sepals*. These are generally green, but sometimes (as in the fuchsia, larkspur, and nasturtium) they are coloured. They are generally arranged in one circle, but in the strawberry there are two, and in the cotton plant three.

A remarkable form of calyx, known as the *pappus* [Latin for *thistledown*], is found in some composite (and other) flowers. The sepals become hair-like, and are often very much enlarged upon the fruit, as is seen in the head of the dandelion after flowering.

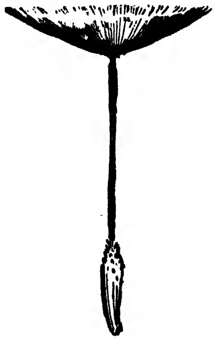


FIG. 144.—Pappus of Dandelion.

Corolla.—The next whorl is the *corolla*, which is generally brightly coloured and often odorous. The parts composing it are called *petals*. When the calyx and the corolla are alike in colour (as in the tulip and the daffodil) they are called the *perianth*.

Stamens.—The next whorl consists of *stamens*. Each stamen, when complete, is made up of three parts—

(1) The *filament*, the stalk which attaches it to the rest of the flower.

(2) The *anther*, a little knob (really a box) on the top of the filament.

(3) The *pollen*, a fine powder within the anther.

Pistil.—The inner whorl is called the *pistil*, which is made up of

Carpels.—Each carpel, when complete, consists of three parts—

(1) The *ovary*, the swollen lower part. It is a hollow box containing one or more rounded bodies called *ovules*.

(2) The *style*, a stalk standing on the ovary, and holding

(3) The *stigma*.

Generally the carpels of the pistil are united together—either

entirely, as in the lily, or the ovaries are united while the styles and stigmas are free, as in the sea-lavender (Fig. 146).

FIG. 145.—Pistil of Lily.

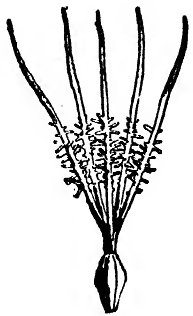


FIG. 146.

Fertilisation.—The stamens and pistil are the most important parts of a flower, for without them fertilisation could not take place, and no fruit or seed could be produced.

Before fertilisation can take place the pollen of the stamens must come in contact with the pistils.

First a grain of pollen settles on the stigma and adheres to it. Then a portion of the inner part of the grain protrudes through the outer part. This prolongation is known as a *pollen tube.* The pollen tube grows down through the style and enters the ovary.

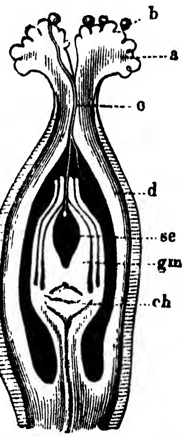


FIG. 147.—Longitudinal section through ovary at time of flowering: *a*, stigma; *b*, pollen grains; *c*, pollen tube; *d*, wall of ovary.

Cross-fertilisation.—In very many cases stamens and pistils are found on the same flower, but, as a rule, the ovary of one flower must be fertilised by pollen from the stamens of another. This process is called *cross-fertilisation.* The pollen is carried from one flower to another in various ways.

(1) *By the wind.*—The flowers of the hazel (the catkins);

for example, are of two kinds—'male' flowers, having stamens and no pistils, and 'female' flowers, having pistils and no

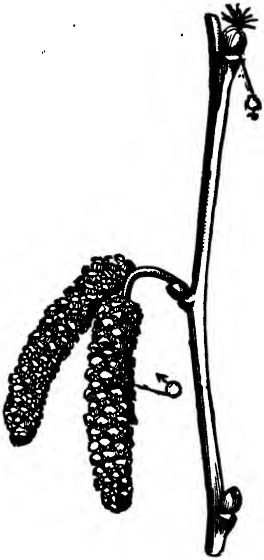


FIG. 148.—Hazel branch with male and female flowers. [The two large catkins are the male flowers; the female flower is at the top.]

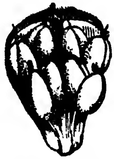


FIG. 149.—Male flower of Hazel.

FIG. 150.—Female flower of Hazel.

stamens. When the pollen is fully ripe it is shed from the anthers and scattered by the wind. The greater portion of it is wasted, but some falls on the stigmas, fertilising them. The oak, the fir, the yew, and various grasses and cereals are thus fertilised. In all these cases the pollen is produced in a far greater quantity than is actually needed for fertilisation. So much pollen is given off into the air in fir forests that when it is washed down by the rain it produces what are popularly known as 'sulphur showers.'

(2) *By insects.*—The brilliant colours and sweet smell of flowers attract insects. While they are endeavouring to obtain the honey they come in contact with the anthers. Grains of pollen adhere to their bodies, and are caught on the sticky stigmas of the next flowers visited. Wind-fertilised plants, not needing to attract insects, have small and inconspicuous flowers.

(3) Some plants are fertilised by birds, and a few by snails.

FRUIT AND SEED

[Two lessons.]

Fruit.—The term 'fruit' is applied to the ripe pistil, formed in various ways, with or without other parts of the flower.

(1) Some, such as the pea, bean, vetch, consist of the pistil alone (slightly altered).

(2) Some consist of the pistil changed entirely into a juicy mass, as in the grape, or partly, as in the peach and plum.

(3) Some, such as the gooseberry, currant, apple, and pear consist of the pistil and calyx. A portion of the calyx may be seen at the top of these fruits.

(4) In the hazel nut the 'nut' is formed from the pistil and the husks from the bracts. The bracts form the cup of the acorn.

(5) The fleshy part of the strawberry is the enlarged receptacle of the flower, the pips being the true fruit.

(6) The mulberry, pineapple, fir-cone, and figs are made up of a number of pistils formed by separate flowers all combined into one mass.

Two kinds of fruit.—Fruits are divided by botanists into two classes:—

(1) Those that open to scatter the seeds.

(2) Those that do not open.

FIG. 151.—Capsule of Primula.

FIG. 152.—Capsule of Poppy.

FIG. 153.—Pea.

Fruits that open.—When a fruit opens so that the seeds fall out it is called a *capsule*. Various forms of capsule are

seen in the primula, poppy, pea (or bean), peony, wallflower, &c.

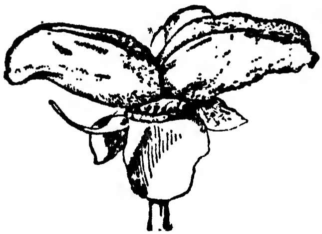


FIG. 154.—Fruit of Peony.

FIG. 155.—Fruit of Wallflower.

Fruits that do not open.—Among fruits that do not open may be noticed—

(1) *The stone fruit* [*drupe*], as the peach, cherry, &c. These consist of three parts : (*a*) the skin, (*b*) the fleshy part, (*c*) the stone (with the seed inside).

FIG. 156.—Longitudinal section through drupe of Peach.

FIG. 157.—Transverse section through a Gooseberry.

(2) *The berry*, where the seeds are enclosed in a pulpy matter within a covering formed by the wall of the ripe ovary alone, as in the grape and potato-apple ; or by the ovary in combination with the calyx, as in the gooseberry and currant.

[The calyx is the brownish, leafy part at the top cut off before the fruit is eaten.]

(3) *The apple and pear* are a kind of berry formed by the enlargement of the receptacle of the flower. The core is the true fruit. There are usually five cavities containing the seeds. The scales on the top are the remains of the calyx.

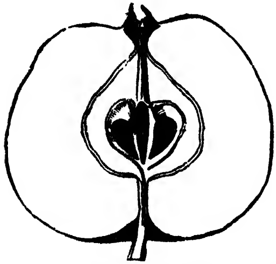


FIG. 158.—Longitudinal section through an Apple.

FIG. 159. Achene.

FIG. 160. Strawberry.

(4) *The achene*,[1] a dry, single-seeded fruit, such as is seen in each floret of the sunflower and dandelion, also in the buttercup and strawberry.

FIG. 161.—Hazel Nut.

FIG. 162.—Acorn.

(5) *The nut and acorn* are a kind of achene in which the seed has a hard shell partly covered with the bracts.

[1] Pronounced *a'-keen*.

The seed.—The seed is usually contained in the fruit. Give examples. The fir is an illustration of a 'naked' seed—that is, of a seed not contained in the fruit.

To be complete the seed must contain the rudiment of the young plant—the *embryo.* Sometimes (as in the pea and bean) the embryo forms nearly the whole of the seed; sometimes (as in the campion) it forms only part. In these cases there is a separate store of nourishing matter called *albumen*, which is taken up by the plant in the early stages of its growth.

FLOWERLESS PLANTS

Types.—The plants which we have hitherto been observing all have flowers, but there are a number of common plants without any. Examples:—Ferns, horse-tails, mosses, mushrooms, lichens, sea-weeds.

Ferns.—The ferns found in the British Isles generally have a simple or branched creeping underground stem, but in New Zealand and elsewhere are found tree-ferns with tall, upright, unbranched trunks.

The leaves are generally called *fronds.* They are rolled up when young, and when older they are thrown off periodically. The stem, which is surrounded by their withered bases, constantly increases in length.

On the under side of some leaves will be found small, brownish, seed-like bodies. These are the spore-cases [*sporangia*]. Each contains within it when ripe what looks like very fine dust. This dust is made up of the spores. When they fall to the ground they germinate, but do not immediately produce fresh ferns. [The complete process of reproduction is too complex for description to young children.]

Horse-tails.—These are found in temperate countries. They have erect, hollow, and jointed stems. The stems are of two kinds, fertile and barren. The fertile stem is generally unbranched, and has at the end a cone-like catkin, consisting of scales having spore-cases on the under side. The barren

generally give off slender-jointed branches in whorls from the joints. [Development from spores, as in the case of ferns.]

Mosses.—Minute leafy plants with slender stems, bearing spore-cases upon erect hair-like stalks. They grow in tufts or in soft carpet-like masses.

Mushrooms.—A full-grown mushroom consists of a vertical stem supporting a cap. On the under side of the cap are the gills, which radiate from the stem but do not touch it. Many mushrooms are poisonous. The edible mushroom has gills at first of a rose colour, afterwards changing to a dark colour. The spores are almost black.

Lichens.—These may be seen as a grey or greenish-yellow crust growing on old walls, trees, fences, &c., or on the ground amongst mosses.

Sea-weeds.—This family [the *Algæ*] includes not only sea-weeds but the green plants found growing in fresh water in the spring and summer.

APPENDIX

SCHEMES OF OBJECT AND SCIENCE LESSONS

A. THE SCHOOL BOARD FOR LONDON

INSTRUCTIONS TO TEACHERS ON OBJECT LESSONS AND ELEMENTARY SCIENCE[1]

INFANTS' SCHOOLS.

THE Government Code requires that arrangements should be made for simple lessons on objects, and on the phenomena of nature and of common life.

The aim of these lessons should be—To develop in the children's minds an interest in the things around and about them; to teach the use of all the senses and form habits of observation; to impart a correct knowledge of the commonest things; to increase the infants' vocabulary and power of expressing themselves.

In order to carry this out, it will be necessary to talk with the children about the objects around them in such a way as to draw out their own powers of perception and thought. The objects thus conversed about should not be many in number, and should, if possible, be the real things themselves; if that is impossible, models should be used, or correctly-coloured pictures. The objects should be in sufficiently large quantities to be inspected, handled, and perhaps tasted and smelt by each child, and their several parts should be pointed out and named with their more simple qualities

[1] Appendix V. to the Board's Code of Regulations and Instructions for the Guidance of Managers and Teachers.

and uses. In some cases also it is necessary that the objects should be taken to pieces, dissolved, or burnt in order to make their properties evident.

The lessons in the earliest stage should, at first, be based on the facts of home life which are within the observation and knowledge of the 'babies.' The baby-room should, therefore, be made as nearly as possible like the home, and should contain familiar household objects, or, at least, pictures of them. The lessons should be conversational, and the teacher should suggest and guide the conversation rather than monopolise it. These lessons might spring from a well-drawn picture of home-scenes, such as take place in the lives of most children, 'Up in the morning early,' 'Father's return,' &c. The first of these pictures must represent the interior of a home, with various domestic objects, each of which might form the subject of a separate 'chat.' The clock is, perhaps, singled out, and the children are asked to observe that in the schoolroom carefully for a few seconds. The 'action song' about the clock should be then sung or practised. The teacher should be careful in this early stage to subject the children to as little restraint as possible and to aim at surrounding the school baby-room with as much of the spirit of a well-ordered and cheerful home as the circumstances will permit.

With the children of five years of age and upwards the teaching may be more systematic, and at least four half-hours in the week should be devoted to it. It will also be naturally co-ordinated with kindergarten and literary lessons. Thus the lesson on the Hen might be associated with the tracing of the picture of a hen, with a movement song about 'Hens and chickens,' and with writing or reading the word 'H e n.'

A few objects should be selected from each of the four following groups :—

1. *Domestic Group.*—The schoolroom itself, with door, chair, table, desk, fireplace, and clock. The child's coat, cloak, frock, cap, shawl, and boots. Pins, needles, knife, scissors, bell, and kettle ; to which may be added any other articles of school or house furniture, clothing, or common utensils.

2. *Animal Group.*—First in importance comes the child itself, afterwards the cat, dog, horse, cow, sheep, cock and hen, sparrow, herring, fly, beetle, to which may be added any other familiar animals, such as donkey, rabbit, mouse, goose, canary, lark, pigeon, shrimp, crab, lobster, sole, plaice, spider, butterfly, bee, periwinkle, oyster, earth-worm, &c. The parts of

animals may form the subject of lessons, such as head, hand, foot, paw, eye, ear, mouth, nose, hair, feathers, wool, &c.

3. *Plant Group.*—The choice will depend upon the season of the year, and should include the nearest trees, and such smaller plants as are accessible, as the primrose, violet, daisy, crocus, dandelion, wallflower, hyacinth, geranium, and fuchsia, holly, cabbage, pea, bean, potato, onion, carrot, turnip, wheat, barley, oats. The parts of plants may also form subjects of lessons, as the wood, bark, leaves, flowers, seed, root, stems, &c., or special products, as apples, nuts, starch, sugar, gum. Attention should also be drawn to the simple phenomena of vegetable growth, by means of actual observation or experiment.

4. *Mineral Group.*—This should include any accessible stone, with chalk, sand, coal, salt, blacklead, and water, together with iron, brick, clay, sulphur, glass, &c.

Opportunity should be taken of bright sunshine, black clouds, fogs, heavy showers of hail, rain, or snow, strong wind, a rainbow, or a thunderstorm, to draw attention to these natural phenomena.

The Board Inspector at his visit will ask the teacher to name the subjects which have been talked about with her children. He will then examine the class upon such of these subjects as he may choose, endeavouring to elicit not so much what is the knowledge as what is the intelligence of the children.

The children should be encouraged to bring the different objects if they are not already in the schoolroom. The Board furnishes the necessary pictures, blackboards, and chalk, and the small case of apparatus referred to in the regulations.

Boys' and Girls' Schools.

It is required by the Board that each teacher shall adopt a scheme of elementary science, in the form prescribed by the Code, of a progressive course of simple lessons adapted to cultivate habits of exact observation, statement, and reasoning. This must be submitted to H.M. Inspector if the children are to be examined in this subject for a grant.

The following is suggested as a model scheme, but teachers have full liberty to vary it according to their taste and acquirements :—

Standard I.	Standard II.	Standard III.	Standard IV.	Standard V.	Standard VI.	Standard VII.
Extension of the object lessons in the infant school, with simple illustrative experiments.	Comparison of different plants or animals.	Simple principles of classification of plants and animals.	More complete classification of plants and animals, with typical examples.	(*a*) Animal and plant life with the most useful products;	(*a*) Animal and plant life, with special reference to the laws of health;	(*a*) Distribution of plants and animals, and the races of mankind;
				or,	or,	or,
	Ordinary phenomena of the earth and atmosphere.	Further phenomena of the earth and atmosphere.	The three forms of matter familiarly illustrated.	(*b*) More definite notions of matter and force illustrated by simple machinery or apparatus.	(*b*) The commonest elements and their compounds.	(*b*) Light, heat, and electricity, and their applications.
	Substances of domestic use.	Substances used in the arts and manufactures.				
					The mechanical powers.	

STANDARD I.

Where the first standard in a school is composed of backward children, nothing more can be attempted with them than has already been laid down for the infants' school. Much time is necessarily given to prepare them in reading, writing, and arithmetic, but two half-hours a week or more devoted to lessons on familiar objects or animals will relieve the more mechanical work, refresh the children's minds, and improve their general intelligence.

Where the first standard is composed of children that have already passed through the infants' school, the previous training of the object lessons should be carried on with more reference to the exercise of the judgment. The list of objects under the four groups may be somewhat extended, especially in the natural history lessons, in which foreign animals and plants, such as elephant, bear, whale, lion, eagle, crocodile, coral, sponge, palm tree, orange tree, tea plant, coffee plant; and vegetable products, such as rice, arrowroot, sago, tapioca, olive oil, cocoanut, raisins, currants, figs, pepper, ginger, mustard and caraway seeds, may be occasionally introduced.

A few interesting lessons may also be given by experiments on water, illustrating the solid, liquid, and gaseous conditions of the same substance; by other experiments on wax, solder, camphor, &c., also illustrative of melting, boiling, condensing, freezing, or subliming; or by experiments on sugar, salt, alum, sulphate of copper, &c., illustrative of the processes of dissolving and regaining the same substance by evaporation or crystallisation.

The lessons should be made as synthetic as possible, and should be carefully graduated, the earlier ones preparing the ground for the later ones.

The reading-book will, however, occasionally suggest object lessons out of the ordinary course.

The Inspector will examine as before, with special reference to the comparison of one object with another, and the uses to which they may be applied. For these extended lessons and experiments diagrams will be provided, together with materials not easily procurable by the scholars themselves.

STANDARDS II., III., AND IV.

In these standards the teaching must be more advanced, and should make a larger demand on the thinking powers of the children.

The objects contained in the previous groups should be again employed, but fresh ones should be occasionally introduced, especially for the purpose of comparison.

In the animal group children should be led to compare and classify the different animals, and to notice the chief differences and resemblances between the leading divisions of the animal kingdom. The children should also have explained to them the preparation, qualities, and uses of animal substances employed in the arts, such as leather, silk, wool, and horn.

In the vegetable group such distinctions as that of endogen and exogen should be made clear; the gradual growth of plants, such as beans and wheat, should be traced; the uses of vegetable substances, such as cotton, linen, starch, sugar, coffee, tea, and indiarubber, with the processes of manufacture, should be explained.

In the mineral group attention should be called to the general properties of metals, iron, copper, silver, gold, lead, tin, zinc, mercury, &c., and the qualities peculiar to each. The iron and steel manufactures, and the making of bricks, pottery, earthenware, &c., may be explained; and the distillation of coal and manufacture of gas may be experimentally illustrated.

The science lesson may be connected, as occasion offers, with the lessons in geography, and may often be used incidentally to illustrate reading and dictation lessons.

The teacher is not expected to attempt to teach all the subjects mentioned in the preceding paragraphs, nor to limit himself to them; but the Inspector will inquire for a copy of the scheme adopted, and will frame his examination in accordance with it, taking care that the fundamental facts connected with matter and force are not overlooked.

Most of the objects required will still be procurable by the children themselves, but the Board furnishes diagrams of the various classes of animated nature, selected specimens, a case of apparatus as before, and, in addition, loan collections illustrating the history of the manufactured substance from the raw material to the final product.

Standards V., VI., and VII.

More advanced lessons, on the principles which are at the foundation of all physical, mechanical, and chemical science, should be given; during which clear ideas should be imparted as to size, weight, and specific gravity, as to the laws of motion of solids liquids, and gaseous bodies, as to the production, radiation, conduc-

tion, and absorption of heat, as to the cause of colour, and as to the difference between chemical combination and the mere mixture of the constituents. The correlation of the different forces should be pointed out. Occasional lessons also on the atmosphere and its composition and the ordinary meteorological changes should be given, and local phenomena of springs, streams, hills, ponds, excavations of the soil, &c., should be observed. If, as is probable, some scientific specific subject be taken, the scheme of elementary science as a class subject must be modified accordingly. Thus, if physiology be taken as a specific subject, the instruction under this scheme should be mainly physical; if mechanics, mainly biological. Boys as well as girls should be taught something of the laws of health. Domestic economy should not be taught empirically, but the scientific principles involved in the lighting of a fire, in cooking, in the choice of clothing material, in washing, and in ventilation should be experimentally explained.

In fact, all the scientific specific subjects should be taught as far as possible by an appeal to the senses.

The Board Inspector will inquire as to the scheme adopted in the higher standards, and will conduct his examination accordingly.

The Board supplies the books and diagrams necessary for teaching these subjects, and illustrative models may be had on loan. As far as practicable, children should be encouraged to make their own models and apparatus, but what cannot be so made will be supplied. The experimental illustrations required for teaching domestic economy are matters of special provision.

A SCHEME OF OBJECT LESSONS AND SCIENCE TEACHING FOR STANDARDS I. TO VII.[1]

Standard I.—Boys and Girls.

I. LESSONS FROM COMMON OBJECTS.

1. *Plastic substances.*

Clay.—Its chief physical properties; changes produced by baking. Its uses for modelling and for making bricks, tiles, drain-pipes, pottery, &c.

[1] This scheme was prepared by Mr. Ricks, one of the Board Inspectors, and the author of two volumes of excellent Notes of Lessons. It was forwarded to teachers to serve as a suggestive guide in the preparation of systematic courses of object lessons.

Putty.—Made of crushed chalk and linseed oil—why *linseed* oil? Its uses to be illustrated.

Gutta-percha.—Comparison of properties when cold and when warmed in hot water. Articles made of gutta-percha.

These lessons to be illustrated with prepared clay, putty, and gutta-percha, which are to be placed in the hands of the children for test and experiment.

2. *Soluble substances.*—Meaning of *soluble.*

Sugar.—Its chief physical properties.

Rock-salt.—Its chief physical properties.

These substances to be placed in the hands of the children for examination and comparison.

Show, by means of the evaporating-dish, how sugar can be recovered from the water which holds it in solution; and how table-salt is prepared from sea-water and from brine springs.

3. *Some substances which burn.*

Coal.—Its physical properties and uses. Heated in a closed vessel gives off gas, which will burn, but which we cannot see. Illustrate with coal-dust in a clay pipe. Compare with other bodies which will burn, such as sulphur, wood, cork, and india-rubber, and illustrate in each case. Show also that animal substances, unlike vegetable, burn with difficulty. Illustrate with wool, sponge, leather, feathers, and whalebone. Compare with fibrous asbestos, which gets white hot in a flame but is not consumed.

4. *Elastic substances.*

Indiarubber, cork, sponge.—Their chief physical properties, and uses.

Illustrate the different kinds of elasticity by a comparison of these substances. How cold affects the elasticity of indiarubber. Manufacture of 'elastic.' Uses to which these substances are put dependent on their special properties.

II. Lessons from Plants.

1. *Parts of a plant: Roots, stems, branches, buds, leaves, flowers, fruit, seeds.*—Uses of these various organs treated in the simplest possible way. *Roots*, to take up food in solution from the soil; *stems and branches*, to carry the earth food to the leaves, and to support the leaves in the air and sunlight; *leaves*, to take in air, and to prepare the plant food necessary to the growth of the plant; *flowers*, to produce fruit and seeds.

2. *Comparison of leaves.*—The general shape, the margin, the

colour, the veins, &c., to be compared from actual specimens *in the hands of the children.*

III. Lessons from Animals.

1. *The cat.*—Covering of hair and fur. The paws and claws, structure and uses. The eyes for seeing with a minimum amount of light. The rough dry tongue, and its special use. The sharp pointed teeth, and their special use. The motion of the lower jaw, and why. Food, and how captured. Disposition. Some of the cat's larger relations—lion and tiger.

2. *The dog.*—Covering of hair. The paws and claws, their uses. The large eyes and smooth wet tongue. The sharp pointed teeth, and special use. Motion of the lower jaw—why? Food, and how captured. Sense of smell very acute. Disposition. Compare in all respects with the cat.

3. *The sheep.*—Covering of wool: uses of wool. Food, and how chewed; motion of the lower jaw. Teeth—flat-topped grinders, absence of incisors and presence of pad in front of upper jaw. Structure of feet: number of toes, and how they are covered. (Mutton and lamb).

4. *The pig.*—Hairs and bristles; compare with fur and wool. Shape of head; the snout and its use. The cloven foot; number of toes. Tusks of wild boar. (Bacon and ham). Compare in all respects with the cat, dog, and sheep.

Standard II.—Boys and Girls.

I. Lessons from Common Objects.

1. *Porous substances.*—Meaning of *porous.*

Sponge, charcoal, blotting-paper, flannel. — Their physical properties and uses. Sponge—how specially adapted for cleansing purposes. Blotting-paper—how it takes up surplus ink; compare with writing paper. Show how a roll of blotting-paper takes up a liquid, and compare with wick of candle. Illustrate by burning turpentine which has ascended through a piece of cane.

Filters.—Make sponge, charcoal, and blotting-paper filters. Illustrate their use. Filter a mixture of chalk and water, or flour and water, or ink through blotting-paper. The earth a filter. Clear water from springs.

2. *Soluble substances.*

Soda, alum, and camphor (in spirits of wine). Physical properties and uses of these substances. Why we cannot see bodies

in solution. Why raw starch makes water milky-looking. Use of soda for cleansing purposes. Soap made from fats and soda.

Further illustrate *soluble* (1) by making saturated solution of alum in boiling water; stand in the solution some wire trinket, the wire being covered with worsted, and set aside to cool; (2) by adding to solution of salt a few drops of nitrate of silver solution, then a little ammonia solution; (3) by adding a drop of water to spirit solution of camphor.

3. *Adhesive substances.*—Meaning of *adhesive*. *Glue*, *gum*, *sealing-wax*, *mortar*, *cement*, *plaster of Paris*. Special uses of these bodies. Illustrate by experiment in each case. Show how sealing-wax and plaster of Paris may be used for making casts. [In mixing plaster of Paris add the powder to the water gradually and not the water to the powder.]

4. *Metals.*

Iron, *copper*, *lead*, *tin*, *zinc*, *gold*, *silver*, when clean and polished are all alike in being lustrous. Iron *rusts* away in time; copper, lead, tin, and zinc rust a little on the *surface* only; gold and silver do not rust.

These metals are *hard* and *heavy*, and can be melted; but they vary in hardness and weight and the ease with which they can be melted.

After experimental illustration, these metals to be arranged as far as possible in order (1) of hardness, (2) of weight, (3) of fusibility.

Some metals can be hammered into sheets or drawn out into wires. Show specimens of sheets of iron, lead, copper, and zinc; also tin and zinc and copper foil, and gold leaf. Also wires of all kinds.

Compare as to malleability and ductility.

II. Lessons from Plants.

1. *Starch.*—Illustrate its preparation from wheat-flour or potato. Made chiefly from rice and Indian corn. *Starch foods*—corn-flour, sago, tapioca, and arrowroot. Illustrate the action of hot water on a mixture of starch in a little cold water; use in laundry, also for stiffening calico, and for making British gum for postage stamps and envelopes.

2. *Sugar.*—Its preparation from the cane or from beetroot. Its special properties and uses. Sugar in fruits. Compare with starch as to properties.

3. *Wheat.*—Description of the growth of the plant. The stalk

the leaves, the ear of corn. Wheaten flour, why the best for making bread.

4. *Rice.*—Its cultivation to be described. Its use for food and for making starch. Rice-flour, why not used for bread-making. Compare with wheat and refer to other cereals, such as maize, barley, and oats.

III. Lessons from Animals.

1. *The cow.*—Covering of hair. Food, and how chewed. Compare with sheep. Structure of feet. *Beef. Milk*, its chief properties and uses. Preparation of butter and cheese.

2. *The horse.*—Special points in structure: the skin, mane, tail, hoofs, gap between front and back teeth. Special uses of tail and hoof. Shoeing. Compare with the donkey.

3. *The rabbit.*—Covering of fur. Long ears. Why? *Gnawing* animals. Why so called? Structure and growth of front teeth. Compare with carpenter's chisel. Whiskers, their special use. Thick blunt claws, their use. Compare with the hare.

4. *The monkey.*—Why called four-handed. Adapted to live in trees. Structure adapted to habit. In some, the tail a fifth hand.

5. *The mole.*—Structure fitted to underground habit. Its fur; why it does not ruffle. The snout. The shovel-like fore paws. The nails. How adapted for tunnelling. The minute eyes deeply set. Why? Habits of the mole. Its food. Its disposition.

Standard III.—Boys and Girls.

I. Lessons from Physics.

1. *Liquids.*—May be made to flow in a stream or in drops. Cannot be grasped by the hand. Cannot be made to form a heap. Have no shapes of their own, but take the shapes of the vessels in which they are placed.

Water.—Its special properties as shown by observation and experiment. Ice and steam—how formed. Uses of water dependent on its solvent power. Spring-water, rain-water, sea-water. Compare as to properties.

Mercury.—A liquid metal. Note its chief properties and uses.

Alcohol.—Its chief properties. Its use in the spirit-lamp and as a solvent. Instance camphor.

Paraffin oil.—Its chief properties. Its source. Its uses for lighting and heating. Danger in its use. How to avoid the danger.

2. *Gases.*—How they differ from liquids.

Air.—A substance, invisible, occupies space, has weight, presses equally in all directions. Illustrate by experiments with the air-pump.

Coal-gas. —Its properties and manufacture, illustrated by experiment. Fire-damp. Coal-gas in mines. Choke-damp. Carbonic acid gas. Balloons. How they rise.

Carbonic acid gas.—How made, its properties, its presence in the air, its dangers. Animals exhale it, plants inhale it. Show how it can be poured from one vessel to another, and how it extinguishes a flame.

Water-gas, or vapour.—Always present in the air. Animals and plants exhale it. Illustrate by passing the breath through a tube into a clean glass bottle; also by enclosing a small branch with its leaves in a bottle. Evaporation.

II. Lessons from Botany.

1. *Parts of a plant.*—General description, with uses of the various organs.

2. *Parts of a flower.*—The calyx, sepals, corolla, petals, stamens, anthers, pollen, pistil, ovary, ovules, style, stigma. Special function of the flowers.

3. *Seeds and seedlings.*—Illustrated by the growth of the scarlet-runner and the wheat plant from the seeds. Plants with *two* seed leaves, plants with *one* seed leaf.

4. *Plant fibres.*—Obtained from the *inner bark* of stems. Illustrate with *bast*, *flax*, *hemp*, and *jute*. Preparation from the bark. Compare these fibres as to special properties, and special uses in the manufacture of *textile* fabrics. Specimens of raw and prepared and manufactured articles to be placed in the hands of the children for examination and comparison.

III. Lessons from Zoology.

1. *A bird.*—The covering of feathers. General structure of feathers, quill, shaft, web; properties and uses of each. Wings instead of fore legs. Hollow bones. Why? Beak and tongue. How the bird takes its food. The legs and claws. How some birds perch, and how some run or swim. Take the duck as an example of the class.

2. *A reptile.*—The common *snake* as a type of this class of animals. Adaptation of structure to habit. Elongated form for creeping. Teeth for holding, not for chewing. Arrangement for enlarging the cavity of the mouth for swallowing large prey. Ball and socket joint backbone and ribs—its special purposes.

Frog.—Curious life history. The *tadpole*—its general structure and arrangement for feeding, for breathing, and for locomotion. The *frog*—its eyes, skin, teeth, legs and feet, absence of ribs. How it breathes. Its tongue as an instrument for capturing prey. Comparison of tadpole and frog as to structure and habit. Compare with *toad.* Frogs and toads are classed by themselves as Batrachians, viz., *frog-like* animals.

3. *A fish.*—The *herring* as a type. Shape for cleaving the water. Illustrate with wedges. The covering of scales, and the oil for lubricating. Horny mouth, no tongue. Gills and their use. How fishes move through the water. Illustrate with an oar. Compare with other common fish.

4. *An insect.*—Structure of insects generally. Division into three parts. Peculiar structure of mouth, wings, and legs. How insects breathe. Take the *bee*, *house-fly*, *butterfly*, *silkworm*, *beetle*, and *cockroach* as examples.

5. *A spider.*—General structure, and how it differs from an insect. Spider-silk and the various uses to which it is put by the spiders.

Standard IV.—Boys and Girls.

I. Lessons from Mechanics.

1. *Extreme divisibility of matter. Molecules. Cohesion* of molecules. Explanation of three conditions of matter—*solid, liquid, gas. Adhesion: capillary attraction.*

2. *Solids.*—Properties of solids explained; hardness, weight, &c.

3. *Liquids.*—Why the surface of a liquid at rest is always level. Explanation of pressure in liquids. Pressure increases with depth. At the same depth the pressure is equal in all directions. Liquids transmit pressure. Buoyancy of liquids. Floating and submerged bodies. Solid bodies weigh less in water than in air.

4. The *atmosphere.*—Weight of; pressure equal in all directions. Pressure varies with height above the sea-level. The weight of the atmosphere varies. The principle of the *barometer.* The boy's sucker, the syringe, suction pump, and air-pump to be explained and illustrated.

II. Lessons from Heat.

Effect of heat on bodies generally.

Expansion and contraction of solids. Application in artisans' work. Liquefaction of solids by heat. Expansion and contraction of liquids. Remarkable exception in the case of water.

How we measure temperature. *Thermometers.*

BOYS ONLY.

III. LESSONS FROM BOTANY.

1. *The structure of an endogenous stem.*

The oak and the fir; how they differ. Hard woods, soft woods, heartwood, sapwood. Direction of the grain and the medullary rays (silver grain).

Seasoning of wood. Direction of shrinkage. Preservation of wood.

2. *Woods used as timber.*—Enumerate their special properties and uses. Sources of supply.

GIRLS ONLY.

III*a*. LESSONS PREPARATORY TO THE DOMESTIC ECONOMY COURSES.

1. General structure of the human body. The bones and joints, skin, muscle, nerves.

2. Respiration, circulation, digestion. General structure of the organs concerned in each.

3. The atmosphere. Oxygen, nitrogen, carbonic acid, water, vapour, ventilation.

4. Water. Oxygen and hydrogen. Pure and impure water.

5. Carbon and carbonic acid.

BOYS ONLY.

IV. LESSONS FROM ZOOLOGY.

1. Division into *vertebrate* and *invertebrate*.

2. Division of vertebrates into *mammals*, *birds*, *reptiles batrachia*, and *fishes*. Characteristic differences in *structure* in relation to *habit*. The form of the body, the covering of the body the limbs and how used, the mouth, teeth, and tongue.

3. Position of the chief internal organs; their uses and characteristic differences. One animal from each class may be selected as the type.

Standard V.—Boys Only.

I. LESSONS FROM MECHANICS.—[First stage, Schedule IV.]

Matter in three states—solids, liquids, gases. Mechanical properties peculiar to each state. Matter is porous, compressible, elastic. Measurement as practised by the mechanic. Measures of

length, time, velocity, space. [The instruction to be purely descriptive and experimental.]

GIRLS ONLY.

I*a*. DOMESTIC ECONOMY. Stage I.

Food: Its composition and nutritive value. Clothing and washing.

BOYS AND GIRLS.

II. LESSONS FROM HEAT.

1. *Distribution of heat.*—Conduction, radiation, convection.

Conduction.—Good and bad conductors. Clothing.

Radiation.—Good and bad radiators. Radiation and absorption. How heat affects the absorption of watery vapour by the atmosphere. The formation of dew and hoar-frost.

Convection.—Boiling and boiling-point. Effect of pressure on the boiling-point. Distillation. Steam.

2. *Heat the cause of motion in the air.*—Winds, ventilation.

3. *Heat the cause of currents in the ocean.*

4. *Specific heat.*

BOYS AND GIRLS.

III. LESSONS FROM BIOLOGY.

1. *Economic products of plants.*—Preparation and uses of opium, quinine, indigo, olive oil, palm oil, cotton, resin, turpentine, flax, indiarubber.

2. *Introductory lessons on physiology.*

Bones and joints. Locomotion in mammals, and adaptation of bones for same. Teeth of mammals; their chief peculiarities. The skin and its function. Cleanliness. Coverings of animals—hair, fur, wool.

Standard VI.—Boys only.

I. LESSONS FROM MECHANICS. [Third stage, Mechanics, Schedule IV.]

1. The simple mechanical powers—lever, wheel and axle, pulley, inclined plane, wedge, screw. To be illustrated by working models.

2. The parallelogram of velocities and the parallelogram of forces.

3. Liquid pressure—the hydrostatic press.

GIRLS ONLY.

I*a*. DOMESTIC ECONOMY. [Stage II.]

Food: Its functions. The dwelling—warming, cleaning, and ventilation.

BOYS AND GIRLS.

II. LESSONS FROM CHEMISTRY.

Elements and compounds. Chemical combination and mechanical mixture. Simple notion of common processes. The air a *mixture* of gases. Water, a *compound* of oxygen and hydrogen. Combustion. Its products. Some knowledge of the more important non-metallic elements—oxygen, hydrogen, nitrogen, chlorine, carbon, sulphur, phosphorus, acids. Alkalies and salts—meaning of.

BOYS AND GIRLS.

III. LESSONS FROM BIOLOGY.

1. *Geographical distribution of* plants and animals most useful to man. Trade and commerce arising therefrom.

2. *General structure and function of* the lungs, heart, blood-vessels, stomach, intestines, liver, and kidneys. Chief peculiarities and changes of these organs in the vertebrates.

Standard VII.—Boys only.

I. LESSONS FROM PHYSICS.

1. *Sound.*—Its production, transmission, and reflection.

2. *Light.*—Its nature and velocity. Reflection and refraction. Lenses. The rainbow.

GIRLS ONLY.

I*a*. DOMESTIC ECONOMY. [Stage III.]

Food: Its preparation and culinary treatment. Rules for health. The management of a sick room.

BOYS AND GIRLS

LESSONS FROM PHYSIOLOGY.

General idea of the action of the muscles and nerves. The special nerves of sense. Structure of the eye.

Lessons from Hygiene.

1. *Personal hygiene.*—Habits, exercise, rest and sleep, cleanliness, attention to the action of the skin and digestive organs. Indigestion, catching cold, inflammation.

2. *Food and diet.*—Classification and uses of food substances.

3. *Water.*—Kinds of water, sources of water, good drinking water, sources of contamination of water, and deleterious effects; cisterns and wells.

4. *Air.*—Impurities, deleterious gases, ventilation, influence of winds.

5. Treatment of slight wounds and accidents. Cuts, burns, scalds, bleeding, fits, drowning, suffocation, poisoning, bites, stings.

B. REPORT OF THE COMMITTEE OF THE AMERICAN SOCIETY OF NATURALISTS ON SCIENCE IN THE SCHOOLS.

The Committee on the subject of 'Science in the Schools' beg leave to report as follows:—

The vote passed at the New Haven meeting of the Society made it our duty 'to develop a scheme of instruction in natural science to be recommended to the schools.'

In regard to the general topic of 'Science Teaching in the Schools,' we believe the following propositions fairly formulate the views which are held by the members of the Society, and which the Society should use its influence to diffuse:—

1. Instruction in Natural Science should commence in the lowest grades of the primary[1] schools, and should continue throughout the curriculum.

2. In the lower grades the instruction should be chiefly by means of object lessons; and the aim should be to awaken and guide the curiosity of the child in regard to natural phenomena, rather than to present systematised bodies of fact and doctrine.

3. More systematic instruction in the Natural Sciences should be given in the high schools.

4. While the sciences can be more extensively pursued in the

[1] A *primary* school receives pupils from six to ten years old. They are then transferred to the *grammar* school, where they remain till they are fourteen. Above that are the *high* school and the *college*.

English course in the high schools than is practicable in the classical course, it is indispensable for a symmetrical education that a reasonable amount of time should be devoted to Natural Science during the four years of the high school course by students preparing for college.

5. An elementary (but genuine and practical) acquaintance with some one or more departments of Natural Science should be required for admission to college.

Believing that the propositions stated above will command general acceptance, we are aware that there must be difference of opinion among the members of our own Society, and among intelligent educators in general, in regard to detail, and that the precise subjects to be introduced in the curriculum must vary somewhat with the circumstances of different localities. We offer the following, not as necessarily the best scheme, but as a reasonable and practical scheme which may at least serve to illustrate the general principles which we have formulated.

In the primary schools, and in the lower grades of the grammar schools, we would recommend that the study of plants and animals should be the main part of the scientific work. The botanical instruction should commence with such simple exercises as drawing and describing different forms of leaves, and should gradually advance to the easier and more conspicuous flowers, and later to the more obscure and difficult forms of flowers, the fruits and seeds.

The zoological instruction in the lower schools should not attempt a systematic survey of the whole animal kingdom; but attention should be directed chiefly to the most familiar animals, and to those which the pupils can see alive. The common domesticated mammals should first be studied, and later the birds, the lower vertebrates, the insects, crustacea, and mollusks. While the range of zoological instruction must be limited as regards the number of forms studied, those few familiar forms should be so compared with each other as to give the pupils very early some conception of the main lines of biological study—morphology, physiology, taxonomy.

Special prominence should be given to the study of plants and animals which are useful to man in any way; and the teacher may advantageously from time to time give familiar talks in regard to useful products of vegetable and animal origin and the processes of their manufacture.

Attention should also be given to the more obvious character-

istics of the kinds of minerals and rocks common in the region in which any school is situated, and to such geological phenomena as are comparatively simple and easily observed.

A most important feature of the scientific instruction in the lower grades should be to encourage the pupils to collect specimens of all sorts of natural objects, and to make those specimens the subject of object lessons. The curiosity of the children will thereby be rationally cultivated and guided.

The subject of human physiology and hygiene is of so immense practical importance, and so few comparatively of the pupils ever enter the high school that we regard as desirable some attempt to teach the rudiments of the subject in the grammar and even in the primary schools.

We would recommend the introduction of exceedingly rudimentary courses in physics and chemistry in the highest grades of the grammar school.

We would recommend as perhaps the most desirable branches of science to be included in the classical courses in the high school and to be required for admission to college, physical geography phænogamic botany, and human physiology. The first is suggested as tending to keep alive in the student's mind a sympathetic acquaintance with nature in its broader aspects; the second as affording unequalled opportunities for discipline in observation; the third as affording knowledge of the greatest practical importance.

The rudiments of physics and chemistry, which we propose for the grammar schools, will enable physical geography and physiology to be intelligently studied in the early years of the high school course.

For the scholars in the English course in the high school there will naturally be more advanced and systematic instruction in chemistry, physics, and zoology, and also instruction in geology and astronomy; but the classical students may, with propriety, leave these studies until they reach them in the college course. The scientific instruction they will have received in the primary and grammar schools, and the study of the three branches above specified in their high school course, will be sufficient to preserve that natural and wholesome sympathy with nature, the loss of which is now the main obstacle to the successful study of Natural Science in the colleges.

C. MIDDLETOWN, CONNECTICUT.

COURSE OF SCIENCE TEACHING IN THE PUBLIC SCHOOLS.

INTRODUCTION.

The object of elementary lessons in Natural Science is twofold: to train the observing powers and to give information. The former should be especially emphasised in the primary grades, and the two made about equally important in the grammar grades.

The teaching should be chiefly objective. Large, well-defined pictures may be used whenever it is impossible to obtain the real objects; but it should always be borne in mind that the best pictures are poor substitutes for the subjects themselves.

In the lowest grades the teacher should studiously avoid the use of technical terms whose meaning is unknown to the children. The chief object here is not to teach science but close and accurate observation, and to stimulate a keen interest in nature. In no grade should special emphasis be laid upon technical terms and classifications, though somewhat more attention may properly be given to them in the grammar grades. All classifications should, so far as possible, be the result of observation and comparison on the part of the pupils. Let the teacher stimulate, direct, and name. Happy the teacher and fortunate the pupils in this delightful work! The teacher judiciously combines speech and silence. An occasional talk, however, by the teacher on the subject before the class is both proper and desirable. Such talks should furnish information beyond the reach of the pupils' observation.

Every lesson should be carefully prepared. Aimless and irrelevant conversations are profitless. Allow and encourage the freest expression of what the pupils see. Encourage the pupils to collect and bring in specimens. Elicit by judicious questions a description of what they have brought. Give them additional information. If neccessary, postpone the subject till the next day and learn something about it.

GRADE I.

Physiology.—Regions of the body—head, trunk, limbs. Details of external parts. Uses of external organs. Hygiene of the skin—bathing.

Zoology.—Lessons on common mammals—e.g. cat, dog, horse, cow, rat, squirrel. Let the pupils observe, compare, and describe.

these animals as regards their external aspect and habits. Compare these animals with ourselves. Tell stories illustrative of habits of these and other mammals.

Botany.—Lessons on common plants. Teach pupils to distinguish root, stem, leaf. Compare leaves of different plants as regards general form, margin, venation. Require pupils to draw and describe leaves of many plants.

GRADE II.

Physiology.—The framework of the body. Bones, joints, muscles. Exhibit anatomical diagrams. Teach the pupils to find in their own bodies some of the bones which can be easily felt through the skin. Emphasise importance of correct attitudes while the framework ot the body is rapidly growing and taking shape. Warn against stooping shoulders and crooked backs. The teeth —their forms and uses. Emphasise importance of proper mastication. Necessity of cleaning teeth.

Zoology.—Lessons on mammals continued. Special study and comparison of limbs of mammals. Let the pupils find the elbow, wrist, knee, and ankle in the cat, dog, horse, cow, rat, squirrel, and any other mammals of which specimens or pictures may be at hand. Thus teach the idea of homology, though the word should not be used. Compare the teeth of common mammals, and lead pupils to recognise adaptation of different kinds of teeth to different kinds of food. Teach pupils to recognise degrees of resemblance between animals. The cat and the dog resemble each other more than either resembles the horse or the rat. Develop idea of classification. Lead pupils to recognise characters of carnivores, ungulates rodents. Most of the mammals with which the children are familiar are included in these three orders. But tell them about monkeys and kangaroos and other very different forms of mammals, that they may not suppose that all mammals are so included.

Botany.—Different kinds of stems—woody and herbaceous, exogenous and endogenous. By study of numerous examples lead pupils to recognise that exogenous stems usually bear parallel-veined leaves. Distinguish deciduous and evergreen trees. Let the pupils make lists of each.

GRADE III.

Physiology.—Elementary ideas of digestion. Why do we eat? All parts of the body are made of the food which we eat. Food is made into blood, and blood made into all materials of the body.

But our food is mostly solid, and must be made liquid before it can get into the blood. Different substances dissolve in different liquids —e.g. salt in water, camphor-gum in alcohol, iron filings in dilute sulphuric acid. Show these experiments. Body itself must make liquids which will dissolve food. Put lump of sugar in mouth. Mouth fills with saliva, and sugar is dissolved. This illustrates secretion of digestive fluids. But meat will not dissolve in saliva. What does become of it? Show anatomical plate of stomach, and tell about gastric juice. Teach (with use of anatomical diagrams) outlines of anatomy of digestive organs. Show by experiment how much more quickly powdered salt dissolves in water than lumps of rock-salt. Teach importance of thorough mastication. Show gizzard of turkey and explain its use. But we have no gizzard, and hence must not swallow our food whole as the turkey does. Wholesome and unwholesome foods. Alcohol.

Zoology.—Lessons on common birds—e.g., robin, hawk, hen, duck. Let pupils compare these with each other and with mammals. Compare feet and bills of different birds, and show adaptation to habits. Continue lessons on homology of limbs. Let the pupils find elbow, wrist, knee, and ankle in birds. Is the bat a bird? Talks on instincts of birds shown in periodical migrations and nest-building.

Botany.—Lessons on flowers. Select plants with perfect and somewhat conspicuous flowers. Teach pupils to recognise sepals, petals, stamens, pistils. Let pupils describe and draw the parts in a variety of flowers. Study polypetalous flowers first, afterwards monopetalous flowers. Cut open the ovary in large flowers, and show the ovules. Develop the idea that the parts of a flower are altered leaves.

GRADE IV.

Physiology.—Circulation. When food has been made into blood, blood has to be carried to all parts of the body—function of circulation. Show by anatomical plates the outline of anatomy of circulatory apparatus. Let pupils find some of their own veins, and feel pulsation of heart and of arteries in wrist and temple. Respiration. Show difference between inspired and expired air by experiment with lime-water. Burn a candle in a jar, and show that the air in the jar affects lime-water like expired air. Carbonic acid always formed when carbon burns—i.e. when carbon unites with oxygen. Carbon in body and in food. Carbon burns—i.e. unites with oxygen—all over the body. Body runs, like a steam-engine, by burn-

ing carbon. Object of respiration—introduction of oxygen and removal of carbonic acid. Anatomy of respiratory organs. Hygiene of respiration—dress, ventilation. Respiration in aquatic animals. Show gills of fish and respiratory movements in living fish. Fish breathes air dissolved in water. Show presence of such air by warming a beaker of water, and so forming air-bubbles.

Zoology.—Lessons on common reptiles, amphibia, and fishes—e.g. turtle, snake, frog, perch, pickerel, eel. Let pupils observe, compare, and describe. Continue studies of homology of limbs. How many of these animals have two pairs of limbs like those of mammals and birds? Notice external covering of these animals. Their bodies are cold. Why? Respiration of fishes. Is the whale a fish? Metamorphosis of amphibia as shown in changes from tadpole to frog. Teach characters of the three classes—reptiles, amphibia, fishes. Characters possessed in common by mammals, birds, reptiles, amphibia, fishes. Sub-kingdom vertebrata.

Botany.—The pistil of a flower develops into a fruit. Different kinds of fruits. Seeds. Show the embryo in beans and other large seeds. Plant seeds in pots, and show growth of plants from seeds. Cycle of growth, reproduction, death.

Grade V.

Physiology.—Nervous system. Analyse the series of actions when a boy puts his hand on the radiator and finds it too hot. Nervous system a telegraphic system of the body. Brain the central office. Afferent and efferent nerves. Anatomy of the nervous system. Hygiene of the nervous system—stimulants and narcotics.

Zoology.—Study the lobster. Lead pupils to recognise jointed external skeleton, distinct regions of body, jointed limbs. Trace similarity of structure in feelers, jaws and accessory jaws, nippers, legs, and other appendages, including the caudal fin. Cut off edge of carapace on one side and show gills. Contrast articulate type of structure, as shown in lobster, with vertebrate type, as shown in animals previously studied. Compare diagrams of nervous systems in vertebrates and articulates. Compare the crab and the sow-bug with the lobster. Teach the pupils to recognise the common characters which unite these animals in the class crustacea. Study angle-worms as illustrating articulate type in much simpler form—body not differentiated into regions, no jointed appendages. Talks on useful animals.

Botany.—Study more obscure and difficult forms of flowers

than those examined in Grade III. Flowers densely aggregated, as in sunflower, dandelion, daisy. Imperfect flowers, as in willow, oak, chestnut. Flowers with open (gymnospermous) pistil, as in pine, spruce.

GRADE VI.

Physiology.—Briefly review work of previous grades. Special study of the eye. Anatomy of the eye. Illustrate formation of image on retina by use of a large lens. Hygiene of the eye. Injury of eye by use of light too strong, too feeble, unsteady, or improperly placed. Cultivation of near-sightedness by bad positions in reading and writing.

Zoology.—Study common insects, as the bee, butterfly, fly, beetle, squash-bug, dragon-fly, grasshopper. Compare these insects with lobster, sow-bug, and angle-worm, and recognise in all these the common character of articulates. In insects note the characteristic division of body into head, thorax, and abdomen. Compare wings of insects as regards number, form, venation, texture. Show scales from wings of moth and butterfly under microscope. Examine the mouth-parts of those insects which are not too small. Supplement observation with pictures. Under lens examine eyes of insects. Explain their peculiar structure. Metamorphosis of insects. Catch some caterpillars in the fall, and keep them in boxes in the schoolroom. Some of them will probably survive, and appear as moths or butterflies early in the spring. Talks on injurious animals. Show how some animals are useful by destroying injurious animals—e.g. insectivorous birds.

Botany.—Distinction between flowering and flowerless plants. Examples of flowerless plants—ferns, club-mosses, horse-tails, mosses, lichens, fungi, sea-weeds. Show fructification of ferns. Show that the distinction of root, stem, and leaf, so obvious in nearly all flowering plants and in ferns and others of the higher flowerless plants, vanishes entirely in fungi and sea-weeds.

Mineralogy.—Study crystalline form, cleavage, colour, lustre, hardness of some of the minerals common in the vicinity of Middletown—e.g. quartz, feldspar, mica, hornblende, garnet, tourmaline beryl.

GRADE VII.

Physiology.—Senses of hearing, smell, taste.

Zoology.—Study the river mussel. Direct pupils' attention to shell (with its hinge, ligament, mantle impression, and muscular impressions), mantle, gills, palpi, mouth, foot, adductor muscles.

Compare this animal with the oyster and the clam. Note that the former has only one adductor muscle; while the latter has the mantle lobes united, forming a sac which is continued posteriorly in the breathing tubes or siphons. Examine some pond-snails. These will be found to resemble the preceding in their flabby, unjointed bodies, destitute of internal skeleton; but will be seen to differ in having a distinct head with feelers, and a spiral univalve shell. Examine shells of some of the sea-snails. Lead the pupils to recognise characters of lamellibranchiata and gastropoda as classes of the sub-kingdom mollusca. Contrast the mollusca with the vertebrata and articulata. Give some talks on corals, sponges, and other animals lower in the scale than mollusks. Do not let the pupil suppose that the classes he has studied comprise the whole animal kingdom. Talk on geographical distribution of animals. Give a little idea of geological succession of animals.

Botany.—Geographical distribution of plants. Uses of plants. Relation of plants to animals.

Geology.—Gravel, sand, clay. Show that these result from the disintegration of pre-existent rocks. Erosion, transportation, and deposition by water. Study gutters and puddles for illustration of action of aqueous agencies. Conglomerate, sandstone, shale. Show that these result from consolidation of gravel, sand, clay. Visit Portland quarries. Other rocks are sediments not merely consolidated but crystallised by action of internal heat. Study specimens of gneiss and mica schist. Contrast their texture with that of sandstone and other sedimentary rocks. Still other rocks have come up in molten condition from interior of globe—e.g. lava, trap. Talks on volcanoes.

GRADE VIII.

Physiology.—Review nutritive functions, using elementary text-book. Illustrate subject with a few dissections.

Physics.—Elementary text-book. Illustrate with experiments as much as practicable.

GRADE IX.

Physiology.—Review functions of relation, using elementary text-book.

Chemistry.—Elementary text-book. Illustrate with experiments as much as practicable.

D. ENGLISH EDUCATION DEPARTMENT.

ELEMENTARY SCIENCE COURSES.

1. English, Geography, Elementary Science, History, and Needlework are called 'class subjects.'—*New Code, Art.* 15.

2. Not more than two class subjects may be taken by any class.—*Art.* 101 (*e*) (i.)

3. The subjects taken may be different for different classes.—*Art.* 101 (*e*) (ii.)

4. A scheme for examination in class subjects is set out in Schedule II. But if the managers desire they may submit to the Inspector at his annual visit, and the Inspector may approve, for the ensuing year any progressive scheme of lessons in these subjects having a similar scope and aim. Examples of alternative schemes which have been approved by the Department will be found in the Supplementary Schedule following Schedule II.—*Art.* 101 (*e*) (vi.)

SCHEDULE II.—SCHEME FOR EXAMINATION IN ELEMENTARY SCIENCE

Standard I.

Thirty lessons on common objects; e.g.—

A postage stamp, the post, money, a lead pencil, a railway train.

Food and clothing materials, as bread, milk, cotton, wool.

Minerals; natural phenomena, as gold, coal, the day, the year.

Standard II

Thirty lessons on common objects, such as animals, plants, and substances employed in ordinary life—e.g. horse, sparrow, roots, stems, buds, leaves, candles, soap, cork, paper.

Standard III.

Simple principles of classification of plants and animals. Substances used in the arts and manufactures. Phenomena of the earth and atmosphere.

Standard IV.

A more advanced knowledge of special groups of common objects, such as—

(*a*) Animals or plants, with particular reference to agriculture; or

(*b*) Substances employed in arts and manufactures ; or

(*c*) Some simple kinds of physical and mechanical appliances—e.g. the thermometer, barometer, lever, pulley, wheel and axle spirit-level.

Standard V.

(*a*) Animal or plant life ; or

(*b*) The principles and processes involved in one of the chief industries of England ; or

(*c*) The physical and mechanical principles involved in the construction of some common instruments, and of some simple forms of industrial machinery.

Standard VI.

(*a*) Animal and plant life ; or

(*b*) The commonest elements and their compounds ; or

(*c*) The mechanical powers.

Standard VII.

(*a*) Distribution of plants and animals and of the races of mankind ; or

(*b*) Properties of common gases ; or

(*c*) Sound, or light, or heat, or electricity, with applications.

SUPPLEMENT TO SCHEDULE II.—ALTERNATIVE COURSES IN ELEMENTARY SCIENCE.

Any of the following alternative courses may be chosen in schools in which the same subject is not taken up as a specific subject. The courses should be taught throughout the school by means of conversational object lessons in the lower standards, and more systematic instruction with the aid of text-books in the higher standards.

The object lessons given in Standards I. and II. should include in mechanics, botany, and physics some lessons on the phenomena of nature and of common life ; in physiology, on the external structure and habits of animals ; in agriculture, on food substances, familiar animals, and common plants ; in domestic economy, on the principal substances used for food and for clothing. Specimens of a few such topics are given.

If two standards are grouped together, the portion given to the lower standard may be taken one year, and that assigned to the higher standard in the next year, in cases where this is practicable

and consistent with the relation between the two portions; or the two portions may be taken in outline one year, and more fully in the next year.

It is intended that the instruction in elementary science shall be given mainly by experiment and illustration. If these subjects are taught by definition and verbal description, instead of by making the children exercise their own powers of observation, they will be worthless as means of education. The examinations by the Inspectors will be directed so as to elicit from the scholars, as far as possible in their own language, the ideas they have formed of what they have seen.

Course A.—Mechanics.

Standards I and II.

Thirty object lessons; e.g.—

A pair of scales, a pair of bellows, a hammer, a clock, carriage-wheel, building of a house, iron and steel, gold.

Standard III.

Matter in three states—solids, liquids, and gases.

Standard IV.

The mechanical properties peculiar to each state.

Matter is porous, compressible, elastic.

Standard V.

Measurement as practised by the mechanic.

Measures of length, time, velocity, and space.

Standard VI.

Matter in motion. The weight of a body, its inertia and momentum.

Standard VII.

The lever, the wheel and axle, pulleys, the inclined plane, the wedge, the screw. The parallelogram of forces. Examples commonly met with illustrating the mechanical powers.

Course B.—Animal Physiology.

Standards I and II.

Thirty object lessons—e.g. on the external structure and the habits of common animals.

Standard III.

The build of the human body.

Standard IV.

Names and positions of the chief internal organs of the human body.

Standard V.

The properties of muscle. The mechanism of the principal movements of the limbs and of the body as a whole.

Standard VI.

The organs and functions of alimentation, circulation, and respiration.

Standard VII.

The general arrangement of the nervous system. The properties of nerve. Sensation.

COURSE C.—BOTANY.

Standards I and II.

Thirty object lessons; e.g.—
Tea, sugar, coffee, cabbage, carrot, potato.

Standard III.

Characters of the root, stem, and leaves of a plant, illustrated by common flowering plants.

Standard IV.

Characters of the parts of the flower, illustrated by common flowering plants.

Standard V.

The formation of different kinds of fruits. Cells and vessels.

Standard VI.

Functions of the roots, leaves, and different parts of the flower. Food of plants, and manner in which a plant grows.

Standard VII.

The characters of the larger groups and most important families of flowering plants. The comparison of a fern and a moss with a flowering plant.

Course D.—Principles of Agriculture.

Standards I and II.

Thirty object lessons; e.g.—

The usefulness of the various animals kept on a farm, and how they repay kindness and care. Bees. Earthworms. A grain of wheat. Hay. Work in a forge. The work to be done on a farm in the different seasons. Gardening. Garden tools.

Standard III.

The supply of plant food in the soil.

Standard IV.

The necessity for cultivation, and the circumstances making tillage more or less effective.

Standard V.

The principles regulating the more or less perfect supply of plant food.

Standard VI.

Manures as supplemental sources of plant food, and recapitulation of the course for Standard VI.

Standard VII.

The principles regulating the growth of crops, and the variation in their yield and quality.

Course E.—Chemistry.

Standards I and II.

Thirty object lessons on familiar objects—e.g. of the inorganic world.

Standard III.

Properties of the common gases, such as oxygen, hydrogen, nitrogen, and chlorine.

Standard IV.

The chemical character and constituents of pure air, and the nature of the impurities sometimes found in it.

Standard V.

The chemical character and constituents of pure water, and the nature of the impurities sometimes found in it.

Standard VI.

The properties of carbon and its chief inorganic compounds. Non-metallic bodies.

Standard VII.

Metallic bodies. Combination by weight and volume. The use of symbols and chemical formulæ.

Course F.—Sound, Light, and Heat.

Standards I. and II.

Thirty object lessons; e.g.—

Bell, trumpet, tuning-fork, sunlight, primary colours, candle, a fire, boiling water, red-hot poker.

Standard III.

The three modes in which heat may be conveyed from place to place.

Standard IV.

Effects of heat on solids, liquids, and gases. Expansion by heat. The thermometer.

Standard V.

Propagation of light. Intensity, shadows. Reflection, mirrors. Refraction, lenses.

Standard VI.

Elementary explanation of the microscope, camera obscura, and magic lantern. Reflecting and refracting telescopes.

Standard VII.

Propagation of sound. Elementary notions of vibrations and waves. Reflection of sound, echoes.

Course G.—Magnetism and Electricity.

Standards I and II.

Thirty object lessons; e.g.—

Amber, glass, sealing-wax.

Standard III.

Attraction, repulsion, and polarity as illustrated by the magnet. Mariners' compass.

Standard IV.

Attraction of light bodies by rubbed sealing-wax and glass. Experimental proof that there are two forms of electricity. Attraction and repulsion.

Standard V.

Gold-leaf electroscope. Construction of electrophorus, electrical machines, a Leyden jar.

Standard VI.

Voltaic battery and notions of a current. Galvanometer. Electro-magnets.

Standard VII.

Terrestrial magnetism. Chemical effect of a current. Electrolysis. Induced currents. The electric telegraph.

COURSE H.—DOMESTIC ECONOMY (GIRLS).

Standards I. and II.

Thirty object lessons on materials used for food; e.g.—
Flour, meat, vegetables, tea, coffee, milk, fruits, salt.

Standard III.

Chief materials used in clothing and washing; e.g.—
Silk, linen, wool, cotton, fur, leather, washing materials.

Standard IV.

Food—its composition. Clothing and washing.

Standard V.

Food and beverages—their properties and nutritive value and functions. The skin and personal cleanliness.

Standard VI.

Food—its preparation and culinary treatment generally. The dwelling: warming, ventilation, cleaning.

Standard VII.

Food—simple dishes. Rules for health. Common ailments and their remedies. Management of a sick-room.

Course I.—Lessons on Common Things.

Standards I. and II.

Thirty object lessons on the chief tribes of animals and their habits, and on common plants and their growth.

Standard III.

Common inorganic substances and their properties.

Standard IV.

Simple mechanical laws in their application to common life and industries. Pressure of liquids, and gases.

Standard V.

Simple chemical laws in their application to common life and industries.

Standard VI.

Outlines of physiology in its bearing on health and work.

Standard VII.

Other simple physical laws, such as those of light, heat, &c.

NOTES OF A LESSON ON THE CAT.

Age of Children—7 to 9.

Illustrations.—A living cat; a saucer of milk.

HEADS	MATTER	METHOD
FOOD . .	Cats, if left to themselves, live on mice, rats, birds, and other creatures, which they catch alive.	Show the cat. 'What does pussy live on?' [Milk, meat, &c., will probably be given.] 'If we did not give her any food what would she live on?' Emphasise the fact that cats catch their prey alive. The remainder of the lesson will show the adaptability of their structure.
STRUCTURE	*Feet.* — The fore paws have five claws each, the hind paws four, which are not so sharp as those on the fore paws.	Let a child count the claws. Call attention to their shape, their sharpness, and the difference between those on the fore paws and those on the hind paws. 'What are the fore claws used for?' Bring out adaptability of their shape to the work of holding a living animal. 'What does the cat catch with the hind claws?' [Nothing.] 'What are they used for, then?'
	Each claw has a sheath of thick, hard skin into which it can be drawn back.	Let a child feel that the claws are not firmly fixed at the end of the toes. Show the sheath, and illustrate its purpose by making the cat project and retract its claws. 'Suppose the cat's claws were blunt, what would happen when she tried to catch a mouse?' 'What would happen to the claws if they rubbed against the ground as the cat walked?' Hence elicit the use of the sheath. 'Who has ever seen a cat scratch trees or chairs?' 'Why does she do so?' [Perhaps no answer.] Then proceed: 'Why do we cut our nails?' 'How does the cat cut her nails?'
	There is a soft pad under each toe, and one under the middle of each foot.	Let the children see the pads. 'What would a mouse do if it heard the cat coming?' Hence elicit the use of the pads.

See p. 17. This is practically the same lesson as that given in another form on p. 55.

NOTES OF A LESSON ON THE CAT—(*continued*).

HEADS	MATTER	METHOD
STRUCTURE	*Teeth.*—In the front of its mouth the cat has four long, sharp teeth, curving inward. The other teeth are also pointed.	Show the teeth. 'What would a mouse try to do when the cat had caught it?' 'With which teeth does the cat hold it?' Hence elicit adaptability of front teeth. Bring out that back teeth are formed for tearing, not chewing.
	Tongue.—The tongue is rough, having a great number of little hooks pointing backwards fixed all over it.	'How does a cat get all the meat off a bone?' [By licking.] Let the cat lick the hand of a child. [To induce her to do so, put a little milk on it.] Explain the cause of the roughness. 'How does pussy wash herself?' Let the cat lap some milk, the children watching the spoon-like action of the tongue.
	Eye.—The pupil of a cat's eye varies greatly in shape and size. At night it is large and round, but in a bright light it is a narrow slit.	Compare pupil to a hole in a closed shutter. Elicit effect of altering the size. 'When do mice come out of their holes?' 'When does the cat want to see best?'
	Whiskers.—The cat has long whiskers. These act as feelers.	Show whiskers. Let a child touch the ends of some. He will perceive that they are stiff, and notice that the cat feels him. 'Should we feel if the ends of our hair were touched?' 'Why does a blind man use a stick?' 'Why do we hold our hands before us when walking across a room in the dark?' 'When does the cat go about most?' Hence elicit need of feelers, and explain action of whiskers.
	Fur.—The cat's fur is thick and warm, but not oily.	Let a child stroke the cat. Elicit that a cat is a night animal, and the consequent need of a warm coat. 'What does father do to his boots on very wet days?' [Oil them.] 'Why?' 'There being no oil in a cat's fur, what will water do to it?' 'Why does the cat dislike being out in the rain?'

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